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HIGH DRAFTING  
IN  
COTTON SPINNING



# HIGH DRAFTING IN COTTON SPINNING

*by*

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## PREFACE

THE considerable extension of the practice of high drafting and the introduction of modified drafting arrangements for this purpose have led to the production of this work.

Although the main object has been to deal with high-draft arrangements, I have found it necessary to refer to the character of the raw material and to those preliminary operations which affect the process of drawing.

As so little has been written on the subject of drawing, though it is one of the most important operations in cotton spinning, I have dealt somewhat fully with the conditions under which drafting occurs in the ordinary drawing roller arrangements, as a preliminary to a consideration of the newer high-drafting methods.

The various high-drafting arrangements which have been dealt with are fairly representative of the various types in use, the sketches employed showing only such mechanical detail as seemed necessary to a consideration of their action.

Some difficulty has been experienced in tracing the origin of several of the various devices illustrated and referred to in the text, but care has been taken, as far as possible, to indicate this correctly.

Some general considerations involved in high drafting and the advantages claimed from the use of such arrangements are referred to.

C. BARNSHAW.

BLACKBURN,  
*December 1929.*



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## CHAPTER I

### THE RAW MATERIAL

THE value of cotton for manufacturing purposes is, in general, determined by the count of yarn to which it can be spun. The features which govern its ultimate possibilities in this direction may be referred to as its spinning capacity, and the cotton possessing these features collectively in the highest aggregate is capable of being spun to the finest count.

A knowledge of the features of the fibre which affect its successful manipulation into a yarn of the commercial standard required is necessarily of fundamental importance to the spinner. The more important of these features are the General Structure, Length, Thickness, Natural Twist, Strength, and the degree of uniformity in all these features. Others, such as Colour, Lustre, and the amount of foreign matter, are important, but for the present purpose they will not be considered, as they have not necessarily any important effect on the spinning capacity of cotton.

*General Structure.*—The normal cotton fibre is a collapsed tube, open at the root, where it has been detached from the seed, and hollow for the whole of its length except at the tip, where it is solid. Its thickness varies only slightly along a considerable portion of its length, but tapers off at the tip. The relation of length to thickness is one of the important characteristics of the fibre. This ratio varies roughly from about 1000 : 1, in the shortest, to 3000 : 1, in the longest commercial cottons. The length and thickness of the fibre are both important in determining its spinning value, but the relation of length to thickness is a factor to which due regard is not always paid, and it is not improbable that some of the unexpected results, favourable or otherwise, which sometimes occur in mill

practice, arise from somewhat obscure changes in this relation, which commercial methods of sampling cotton may not always reveal. The length can be fairly accurately determined, and it would be most useful if some ready means could be found for obtaining with a reasonable degree of accuracy the ratio of length to thickness.

There is a tendency to base too rigidly upon fibre length the estimate of the count to which cotton can be spun. This should be avoided as it may lead either to the use of cotton which, owing to coarseness of fibre, has not the spinning capacity assumed, or, on the other hand, failure to realise to the full the capacity of a finer cotton of similar length. The respective effects of the length and thickness of the fibre on spinning capacity will be dealt with later, but the importance of the relationship between the two may be emphasised at once.

*Length.*—The length of the cotton fibre is regarded as perhaps the most important single factor in determining its value. If a grip amongst the fibres forming a yarn, sufficient to resist a definite strain before rupture, is necessary, it is obvious that, all other conditions being equal, longer fibres, which are in frictional contact with other fibres in the yarn along a greater length than shorter ones, will offer greater resistance to slipping and make a stronger yarn. It is probably understating the case to say that a fibre  $1\frac{1}{2}$  inches long is in effective frictional contact with other associated fibres for twice the length of a  $\frac{3}{4}$ -inch fibre, as under any system of spinning and with any class of cotton the ends of some of the fibres will be free, and the shorter the fibre the greater the percentage of free length to the whole. If this is conceded, the relative effectiveness of the grip obtained with the longer fibre is even greater than is indicated by relative length. Further, the effectiveness of the grip established amongst the fibres in a yarn, bound together by twist, will vary along the length of each individual fibre, and will normally be greatest at the middle and diminish towards the ends. If the effect of coil friction due to twist increases towards the middle of the fibre length, it is reasonable to assume that the efficiency of the mutual grip between the individual fibres will be greater with the longer than with the shorter fibres.

If it is assumed that yarn breakage under strain is due primarily

to slippage and not to breakage of the fibre, then fibre length, in so far as it affects the mutual grip established amongst fibres associated together in a yarn, will largely determine the strength of the yarn. If, on the other hand, it is assumed that yarn rupture is due primarily to breakage and not to slippage of the fibre, then the greater the length and the more effective the mutual grip, the more fibre breakage will occur before yarn rupture takes place, and the same purpose is served. Whether slippage or breakage is assumed, yarn strength is directly related to fibre length, and the rate of increase of the former is greater than that of the latter, other conditions being equal.

*Thickness.*—The thickness of the fibre affects its spinning capacity in so far as it affects the number of fibres associated together, not only in the yarn, but in the material at every previous stage where drawing rollers are employed. It also affects the resistance to drawing owing to its bulk in every drawing operation, and the compactness of the yarn under the influence of twist.

Since a commercial yarn must have at least a certain standard of strength, if not of uniformity, the coarser cotton will reach its ultimate spinning capacity at a lower count than the finer one, as there will be fewer fibres associated together at every point, the minimum number for strength purposes being reached at a lower count with the coarser than with the finer fibre. Some definite relation exists between the count of yarn to which cotton can be spun and the thickness or sectional area of the fibre, the former increasing as the latter diminishes.

The resistance to drawing will be greater with the coarser fibre owing to its thickness and increased rigidity as well as other factors. This increased resistance will, under most conditions of drawing, necessitate wider roller settings so that the fibres may draw forward without interruption; the result of this wider setting will be to increase the number of fibres out of adequate control with consequent greater irregularity in the yarn.

The coarser fibre will generally, on account of its thickness, draw less smoothly than a finer one, and the operation of drawing will set up greater agitation amongst such fibres, with increased fibre displacement, resulting in a rougher and oozier yarn.

It is difficult to express accurately, in terms of diameter, the thickness of a cotton fibre, but, since the diameter is frequently given to indicate this feature, it is for the present purpose assumed to be related to thickness. On this assumption, if the fibre diameter of two cottons of equal length is  $\frac{1}{1400}$  inch and  $\frac{1}{1800}$  inch respectively, their weight and thickness will vary approximately as the square of the diameters. The number of fibres, therefore, in the cross-sections of yarns spun from these cottons may vary in the proportion of 7 to 8. This difference is sufficient to give the finer cotton greater spinning possibilities, not only by having a greater number of fibres resisting slippage, but a greater probability of uniformity in the diameter, compactness, and smoothness of the yarn.

*Natural Twist.*—This feature of the cotton fibre is to a large extent responsible for establishing the necessary cohesion amongst the fibres, and its effectiveness in this respect will be chiefly governed by the number and the depth of the surface corrugations resulting from fibre twist.

It is necessary to remember that, without natural twist, the value of cotton to the spinner would be very much reduced, as it would very greatly limit its spinning capacity. Whilst it is overstating the case to say that cotton, devoid of natural twist, could not be spun into yarn, it is true to say that it is this feature which gives cotton its important position amongst the short-fibred textile raw materials.

Moreover, as the strength of a yarn is dependent chiefly on the interlocking effect amongst the fibres resulting from it, the amount and the character of the twist are of great importance. Although the actual frequency of the fibre convolutions may be the most important factor in fibre twist, it cannot be assumed that the interlocking effect is determined entirely by this, for the effect of the depth of the surface corrugations resulting from twist must be considered. In normal fibres the surface corrugations formed by twist in a thicker fibre will be deeper and will, individually, have greater interlocking effect than in a finer one. On the other hand, the fibre twists are, from purely physical causes, likely to be fewer in the coarser than in the finer fibre. It is difficult to estimate correctly the relative effect of these factors without regard to other relevant characteristics.

In the manipulative processes, however, particularly in drawing, the finer fibres will be kept under better control, and the improved compactness and increased interlocking effect resulting from this, together with the greater number of interlocking points, will, in general, result in the production of a stronger and smoother yarn from the finer than from the coarser cotton, the relative fibre strength and other factors being equal.

*Strength.*—The ultimate strength of the cotton fibre is very closely allied to its thickness or sectional area, the strength being approximately proportionate to the area of the cross-section. Comparisons of fibre strength are of little value unless they relate strength and thickness ; a cotton fibre is stronger only if its ultimate strength is greater than that of another of equal thickness or sectional area.

Tensile strength tests show that, according to conditions, when a yarn breaks under tension, a widely varying percentage, in some cases low, in other cases high, of the total number of fibres actually break. The strength of the individual fibres will, however, only have a direct effect on yarn strength if the fibres are so bound together that an equal number resist separation to the breaking-point.

The ultimate strength of the fibres, which are so bound together in a yarn that they will break rather than slip, must obviously affect the strength of the yarn, and there are some fibres so associated in almost any yarn with approximately the normal amount of twist. The number of such fibres will vary with the length and natural twist of the fibre as well as with the amount of twist in the yarn. The yarn containing the longest fibres, or fibres with the greatest amount of natural twist, will have most fibres resisting separation to breaking-point.

The strength of a yarn is therefore directly affected by the ultimate strength of those fibres so bound together that they break before they will slip, and the resistance offered to sliding amongst those fibres which will slip before they reach breaking-point. In a soft twisted yarn there will be few of the former, the number increasing as the amount of twist in the yarn increases. For this reason those cottons which are strong and which establish a high degree of mutual fibre friction are used in the harder twisted warp yarns where strength is an important consideration.

In all these features departure from the normal is always present to a varying degree, and whether in length, thickness, natural twist, or strength, it is important. This irregularity is inevitable, and is due primarily to obscure causes in the process of plant and fibre development.

One of the most important of these variable features, and fortunately the one which is most easily ascertained, is irregularity in fibre length, represented diagrammatically in fig. 1, which indicates the approximate variation present in a sample of cotton, as revealed by means of a cotton sorter. It is typical of commercial cotton,



FIG. 1.—FIBRE LENGTH DIAGRAM.

and is included to show both the degree and amount of variation present, and to indicate one of the chief sources of difficulty in the making of uniform yarn. Any increase in the degree and amount of variation in length will normally increase the irregular distribution of the fibres and the irregularity of the yarn, and consequently reduce its strength and general quality.

The variations in thickness, amount of natural twist, and strength of normal fibre always present in any class of cotton, which the ordinary commercial methods of sampling may not adequately reveal, will also limit its usefulness, and deterioration in any of these respects will reduce its spinning capacity. With regard to thickness and fibre strength, it must be remembered that the strength of a cotton hair is the strength of its weakest part. As the presence of a varying number of weak threads will have its effect on the breaking strain of a lea test, so the presence of weak hairs

will have its effect on single yarn strength, there being much in common between the two cases.

An important feature of fibre twist in relation to yarn strength is the degree of uniformity in the pitch of the twists. Those cottons which have a higher degree of uniformity in this respect will, all other conditions being equal, make a stronger and more compact yarn, as they will interlock more efficiently, increasing resistance to sliding amongst all the fibres, so that a greater number of them will resist to breaking-point.

In addition to what has been regarded as variation in normally ripe fibres, consideration must be given to the detrimental effect of the presence of the thin-walled immature fibres, and the over-mature fibres which have become almost solid, the former fragile and ribbon-like, the latter thick and brittle, and both very deficient in natural twist. The effect of these, as well as the presence of abnormally shaped fibres in varying amounts, has to be taken into account in judging the spinning value of cotton, a task which calls for peculiar manipulative skill, judgment, and knowledge to estimate with anything like accuracy the sum-total effect of all the factors at issue.

It is true that the expert in the handling of cotton can judge approximately the general features, and ascertain with reasonable accuracy the spinning capacity of any lot of cotton or its suitability for any particular purpose, but it is more than possible that if suitable special apparatus were available and utilised, some, if not all, of the important features could be revealed with greater accuracy and presented in a more intelligible form. The testing or examination of cotton on these lines is now being regarded with greater favour, and it has the advantage that, if necessary, records can be kept for comparative purposes. This method of testing cotton does not supplant the function of the expert in judging cotton, it only provides information on which judgment may be based, nevertheless, it may be very helpful by increasing the extent and accuracy of the spinners' knowledge of the material, not only at the initial stage, but at any subsequent stage, in mill operations, and may conceivably result in more efficient and economical working.

## CHAPTER II

### MIXING AND BLENDING

THE successful mixing and blending of cotton involves not only good judgment of the raw material, but a thorough knowledge of the manipulative processes, and it is relevant to the purpose of this work to consider some points arising in the mixing of cotton as they affect the production of good yarn.

Amongst the chief requirements for successful mixing are (1) good judgment as to the general features of the components of the mixing; (2) a knowledge of the manner in which the components will blend, and the correct proportion of each to obtain the best results; (3) a knowledge of the action and effect of the opening machines on the cottons, the difference, if any, in treatment required, and the point in the processes at which mixing is most advisable; (4) a correct estimate of the effect on the mixing, of the carding, combing, and subsequent drawing operations in order to produce a satisfactory yarn.

Briefly considering the points enumerated: (1) There is normally a fairly narrow limit set to the variation in length of staple of the component parts of the mixing, although this limit will vary in different circumstances and according to the conditions of drawing. In the case of roller settings inside staple length in the spinning machine, the allowable variation in length may be somewhat greater than when all drawing rollers are definitely weighted.

It is with regard to the less obvious features of the raw material, such as the diameter and fibre twist, that the usual method of judging cotton is liable to be less accurate than as to length. Generally speaking, the best available way of determining the value of these

two factors is to put the material through the machines to the yarn stage, and estimate their effect in the result. This method is so seldom employed, on account of the inconvenience entailed, that the successful introduction of means which will assist in revealing these features with greater accuracy is very desirable. It cannot be definitely assumed, however, that when more accurate information as to length, diameter, and natural twist of the various components of the mixing can be obtained separately, the ultimate effect of these in combination can be estimated quite satisfactorily in terms of yarn.

There is much to be said in favour of the employment of a few small sampling machines to deal with small lots of cotton, as by this means much valuable information, otherwise undisclosed, may be quickly obtained, and the tests can be carried through without interference with production plant.

Before it is put into use every bale of cotton should be examined to ascertain if it is equal to standard in all respects. This is desirable regardless of the weight of cotton used, as it is imperative that material which varies from the required standard should be rejected at the start and not allowed to jeopardise results.

(2) This requires a knowledge of the manner in which the cotton will blend, and the degree to which the various features of the constituent parts are supplementary or complementary to each other, so that it can be treated successfully as a whole and blended together to form a satisfactory yarn. In this connection the best proportion of each of the marks or varieties being mixed can be, in general, only finally determined by putting the mixing through, but it is necessary to ensure that the determined proportion of each is used; hence the arrangements for feeding at the bale-breaker or at any later point should be satisfactory.

It is when mixing in the bale-breaker or in the stack that maximum facility is offered for varying the proportion of the various component parts. There is little doubt that stack mixing provides the best means for the most thorough preliminary blending of the material, besides allowing the cotton, when in a loosened state, to become uniformly conditioned. At the lap or later stages less facility for varying the proportion of the constituents to be mixed exists, and

this consideration may determine the point at which mixing occurs. If, for economic or other reasons, stack mixing is omitted, every care should be taken to ensure that, as far as possible, conditions are such as to prevent the possibility of damp cotton passing forward. The general efficiency of the mixing and opening processes is materially affected by the moisture content of the cotton. It is important that the material under treatment should be uniformly conditioned in this respect, dry enough for satisfactory opening and cleaning, but not excessively dry, or soft laps, with the irregularity associated with such laps, may result.

(3) In the mixing of cottons which vary considerably in strength and in the amount and character of the foreign matter associated with them it may be advisable, as far as is reasonably possible, to open and clean them separately, having due regard to their thorough mixing and economical working. Any excessive treatment in the opening machines should be avoided, because, in addition to being uneconomical, it may detrimentally affect subsequent results.

In this connection an opening and cleaning plant which, by simple means, provides for the inclusion or exclusion of one or more machines in the set offers, in many cases, obvious advantages. The question of the cost of the cleaned cotton of each component of the mixing requires investigation by treating them separately. The effect on general efficiency when frequent changes in the opening machines are necessary and on the thoroughness or otherwise of the mixing when it occurs at a subsequent stage are both considerations which arise from the mixing of material requiring special preliminary treatment.

The passage of mixed material through the whole or part of the opening machines may result in irregularities in working, and care is necessary if damage to the material, excessive waste losses, or faulty laps are to be avoided. The whole mixing should be thoroughly opened and cleaned, and delivered in a uniformly thick sheet in which the various constituents are thoroughly mixed. The tendency of mixed material, the component parts of which vary considerably in character, to separate in opening machines is somewhat difficult to overcome, and may have its influence in deter-

mining the place at which mixing shall occur so as to obtain a thoroughly homogeneous sheet in which the various constituent parts are properly distributed.

(4) In mixing cottons the amount of waste loss in the carding or combing process is a very important consideration, as it represents a very considerable charge on yarn costs. The amount of loss likely to occur in these processes can be ascertained approximately by the usual method of sampling, but the employment of a fibre sorter may be very useful in indicating more accurately the losses likely to be experienced in these machines. It is generally understood that all fibre below a predetermined length will be removed in combing and in carding a certain percentage of the shorter fibre. It is equally important, however, to realise that, in carding, the removal of short fibre is always accompanied by the loss of a considerable and related amount of fibre of normal length, as the machine is incapable of particular discrimination between long and short fibre.

It is therefore necessary to remember that, in carding, the presence of an abnormal amount of short fibre not only increases the loss of short fibre, but also the loss of good fibre, and, in addition, it has a detrimental effect on the general efficiency of the carding process. Abnormally long fibres in an irregular cotton are no compensation for abnormally short ones; they only introduce additional difficulties, because carding can be more efficiently performed with regular than with irregular cotton.

A reduction in the price of cotton on account of abnormal variation in fibre length, which merely covers financial loss incurred by increased waste loss at the card, or as a matter of fact at any other process, is no adequate recompense, as the efficiency of the carding as well as all other operations on the whole of the material will be detrimentally affected by its use. The effect of the introduction of a new mark or quality in a mixing can only be finally determined when it has been thoroughly tested, both separately and associated with the other constituent parts of the mixing.

It must be realised that the use of cotton from an increased number of sources of supply, however necessary and desirable, has

increased rather than reduced difficulties, not only in opening and carding, but in subsequent processes. Such cottons, having different sources of origin, will, in general, have greater differences in character, and be more difficult to blend satisfactorily, than cottons from one area. Cotton from growing areas in process of development may be more likely to vary in character than cotton from areas where contributory factors in cultivation and marketing are more stabilised.

When cottons of different growths are mixed together, the difficulties experienced in obtaining a uniform running quality may be increased, owing to the differences which may exist in the cotton as a result of conditions of soil, climate, and general methods of cultivation peculiar to its place of origin. These possible differences call for special care when such cotton is introduced into a mixing, and a thorough test should be made to ensure satisfactory results before bulk mixing is carried out.

In view of the enormous amount of cotton available, the problem of getting the cotton which is peculiarly suitable in every way for any particular purpose is a difficult one, and it may be that better organisation, and the employment of better methods of ascertaining more exactly the various features of cotton, may result in considerable economies and other advantages.

Some cottons are more likely to vary from bale to bale and from one delivery to another than others, thus increasing the difficulty of obtaining satisfactory results. If there is no reasonable expectation that a particular type of cotton can be repeated, its value for a great many purposes is much depreciated, for, in these circumstances, the spinner cannot hope to obtain uniformity in yarn quality over successive deliveries. The marks or classes of cotton which have obtained a reputation for uniformity have an added value to the spinner because of this fact. The use of such cotton carries some guarantee that little, if any, change will occur, and it is under such conditions that the best possible results in both quantity and quality of yarn can be obtained. The margin between good and bad working conditions in a mill is usually a narrow one, and maximum output of satisfactory yarn can only be obtained from uniformly running mixings.

The introduction of a new cotton, which appears suitable when

sampled in the usual way, may seriously interfere with working conditions and affect output or quality. If a new cotton is introduced into a mixing the result may be unsatisfactory under present working conditions, though slight modifications of existing conditions might produce satisfactory results. One of the practical difficulties in the way of changes in the compositions of mixing and the introduction of new marks is the general absence of any facilities for the experimental mixing and processing of the material to the yarn stage.

The considerable extension of finishing processes and the increased production of standardised finished goods have made it even more necessary for the spinner to avoid changes in the mixing which are likely to produce difficulties and faults in the yarn or in the material at subsequent processes. Such faulty material as irregular, dirty, or neppy yarn is obvious in the grey, but the presence of unripe cotton and the mixing of different growths may produce faults which, though not apparent in the grey, will after bleaching, dyeing, and finishing be revealed with serious consequences. The most important feature of any yarn, to the spinner as the finished product and to the manufacturer or doubler as raw material, is conformity to the standard, and it is to the attainment of this end that the whole skill and attention of the spinner should be directed.

It is necessary in all circumstances, when making mixings, that every possible step should be taken to obtain a thorough blending by amalgamating together as large a representative weight of cotton at the bale-breaker or stack as possible. The method of feeding to the bale-breaker, the working of the machine itself, and the manner in which the cotton is stacked and taken from the stacks are all points which affect the thorough mixing of the cotton and the uniformity of the resultant raw material. The standard of uniformity in yarn quality which is maintained is, in general, a measure of the success of the whole of the mill operations. Uniformity of yarn quality enables a doubler or manufacturer to obtain maximum output and quality in just the same way as the spinner requires uniformity in the raw material to obtain the same result.

The selection of the raw material and its proper mixing are matters of the greatest importance, because an error cannot well be rectified, and will detrimentally affect the output, waste loss, quality of yarn, and cost of production, and indeed the whole working economy and efficiency of the mill. Those responsible for these tasks must not only be expert in correctly estimating the various features of the raw material, but must also have the knowledge necessary to obtain the best results in the mixing and manipulation of the material.

## CHAPTER III

### PRE-DRAWING PROCESSES

THE processes of opening, cleaning, and carding, and, when employed, the additional process of combing, are intended primarily to remove impurities and short fibre, and to separate the fibres from each other. They fulfil a further important purpose, however, in assisting in the thorough mixing of the material used. Almost every machine subsequent to these contributes in some measure to this object, but it is very important that the processes named should function as efficiently as possible within the limits of their capacity in amalgamating or thoroughly mixing the material. Under exceptional circumstances it may be considered desirable to delay mixing until the drawing process or even later, but in general the mixing capacity of these machines is available and is important.

In mixing the raw material the expectation is that in the finished yarn there will be in every part the correct number of fibres from each of the various constituents used according to weight. For example, in making, from cottons of equal length and thickness, a yarn which has an average of sixty-four fibres bound together from an eight-bale mixing, there should be an equal number from each bale present along the whole length, and they should be thoroughly amalgamated. This expectation is, of course, never fully realised, but to obtain the best results in this direction full use of the mixing function of the pre-drawing processes, as well as subsequent processes, should be made.

It is necessary that the fibres in the yarn shall not only be proportionate to the quantities mixed, but that they shall be properly distributed. The difference may not be obvious but it is real and

important, and it is probable that the pre-drawing processes function more perfectly in this respect than the later machines, which only mix by attenuating and folding.

The opening and scutching machines, though only dealing with the cotton in bulk, function as mixing agents by forming a sheet of cotton for the card in which all the material should be adequately opened and properly distributed. Every care should be taken in the method of feeding and in the manipulation of the material in the machines to ensure that this result is obtained in the highest degree. The carding machine, although its action in this respect is not always realised, is in some respects probably the most efficient mixing agent throughout the whole series of processes. It effects a very thorough amalgamation of the component parts fed into it, because in the process the fibres are isolated from each other and dealt with individually.

A brief consideration of the action of the carding machine may be permissible and may be profitable in directing attention to its usefulness in mixing. To assume typical conditions, if 1 foot of lap is fed per minute, the fibres are distributed over approximately 1000 feet of licker-in surface in small groups, which, if the lap has been well prepared, will contain well-distributed and representative amounts of the material mixed. This 1000 feet of material will be attenuated to about 2200 feet on the cylinder surface, in which condition it is subjected to the retarding influence of the flat wire and the combing or carding interaction between the flat and cylinder wire. The effect of this is to isolate the fibres, the cylinder carrying them forward as a fine film at the speed of 2200 feet per minute.

When deposited on the doffer this fine film is condensed or contracted lengthwise about twenty-five times, being delivered at the rate of about 90 feet per minute, and when taken off the doffer the web of 38 inches width is contracted widthwise into a sliver. Thus the fibres forming a film on the cylinder more than 1 yard wide and 2 feet long are all associated in 1 inch of sliver. The assembly of the fibres from such a large area of film formed from the full width of the lap, and the manner in which the fibres are manipulated in the card, combine to give the machine very thorough and highly efficient mixing power.

Mixing at the card is effected in a way peculiar to the machine, not by folding, as in most of the subsequent machines, but by the contraction in length and width of the enormously attenuated film of isolated fibres.

The operations of doubling and drafting may easily be over-estimated as mixing or blending agencies. It is true that the material is mixed to some extent by these operations, but that they do not amalgamate the material so thoroughly as is sometimes supposed can be demonstrated by passing a coloured sliver forward and observing its definable position in the strand from point to point.

It is relevant to a consideration of drafting methods to draw attention to the work of the carding machine in removing the foreign matter remaining in the material as well as nep and short fibre. It is fully realised that the method by which these undesirable elements are removed entails the loss of a considerable amount of good fibre, and considerable attention is focussed on modifications in the type of wire employed in the machine which may tend to reduce the amount of such loss. Provided that the separation of the fibres is effectively performed, if modifications in the character of the carding surfaces result in avoiding some of the loss of good fibre which occurs, even though as a result a smaller amount of short fibre is removed, the consequent economies will be considerable, and it may be that with improved drawing arrangements the resultant yarn will not be detrimentally affected.

It is well to remember that the original purpose of carding was the separation of the fibres from each other, and that it is still its most important object. If this object is not satisfactorily accomplished good results in the drawing operation cannot be obtained, as the fibres have not the free individual movement which is necessary to satisfactory drafting. Although the carded fibres are of necessity formed into a sliver, they should be in a loosely associated condition, and there should be no more cohesion at this point than will form a sliver of sufficient strength to pass into and through the subsequent process under satisfactory conditions.

If the fibres are properly separated in passing round with the cylinder, the disordered condition in which they are condensed on to

the doffer will ensure that the association of the fibres is very loose, leaving them quite free to move individually under the action of drawing rollers. If carding does not affect such a separation of all the fibres, it is highly probable that the small groups of unseparated fibres may be lost as waste in a combed quality, whilst in a carded quality they will pass from point to point in the subsequent machines without being separated and cause uneven or cloudy yarn.

On combed qualities the combing machines operate very efficiently as mixing agents by the dual folding action in the preparatory machines and by the attenuation, width contraction, and subsequent folding which occurs in the comber. On carded qualities, since these agencies are absent, it is highly desirable that the mixing function of the card be assisted to the fullest extent by feeding the machine with a lap, which, besides being well opened and uniformly thick, has the various constituent parts of the mixing satisfactorily distributed throughout its width, length, and thickness.

## CHAPTER IV

### PARALLELISM AND UNIFORMITY

#### PARALLELISM

THE successful application of drawing rollers as a means of attenuating a strand of cotton fibres was in some respects the most important single improvement in the development of cotton spinning on modern lines. Their introduction resulted in the construction of a whole series of machines intended primarily to draft or draw the material, and they became, as they still remain, the most important feature of every machine—the comber excepted—subsequent to carding.

If their original function was considered to be the drawing out or attenuation of the material, it must have been quickly realised that their effect in disposing the fibres in parallel order was highly beneficial, and that the parallelising influence of drafting was so important as to be regarded as one of the important objects of the operation.

It is obvious that, if satisfactory results are to be obtained in the machines where drawing rollers are employed primarily for drafting purposes, the fibres must not only be free to move relatively to each other, but that they must be parallel to each other. The separation of the fibres is, as stated, the chief function of the carding machine, and if not efficiently performed the possibility of producing a really good yarn is jeopardised, since no subsequent machine is likely to effect the separation of the fibres which the carding process has failed to accomplish. These associated fibres may pass forward through all subsequent machines without being separated, and result in unsatisfactory drawing and uneven and cloudy yarn.

In roller drawing, the fibres are drawn parallel as a result of the increase in surface speed of the successive lines of rollers. An inspection of the carded web reveals the fact that the fibres are in a state of disorder, and they may pass in this condition in sliver form to the rollers of the drawing frame, the action of which will now be considered.

In dealing with the precise action of the rollers on the material during drawing, consideration will be given to the conditions existing between the back and next pair of rollers in the first head of drawing, with setting for a medium weight of carded sliver, say about  $\frac{1}{2}$  inch, in excess of staple length. Immediately the fibres emerge from the back line they come under the influence of those fibres which are moving forward at a higher speed under the influence of the next pair of rollers. They are thus at once under the influence of two forces—a retarding force, due to the grip of the rollers and the mass of fibres emerging from the back rollers, and a force in a forward direction exerted by the fibres moving, under the influence of the next pair of rollers, at a higher speed. Whatever position a fibre may occupy, these forces will cause it to take up a position offering least resistance to increased forward movement. When the fibres emerge from the back rollers the retarding force is greater than the forward force, but as they move forward the former force diminishes and the latter increases—the forward force ultimately becoming the greater. It is not difficult to realise that, under such conditions, the fibres will gradually take up a position, only approximately at first, but ultimately, when the process has been repeated sufficiently, lengthwise and parallel in the sliver. This result is capable of easy demonstration, but consideration of the precise action occurring may serve a useful purpose in elucidating some points relating to the further consideration of the action of drawing rollers.

It is apparent that the operation of parallelising the fibres is one that requires easy action at first when the parallelism amongst the fibres is at zero, and a gradually increasing intensity of action as the maximum degree of parallelism is approached. For this reason, as well as for other reasons which will be subsequently referred to, the draft between the back and subsequent pair of rollers in the first

drawing head should only be slight, as it is at this point that the first step towards parallelism occurs, and, owing to their disordered condition, any excess of draft may result in the fibres being drawn forward in an excessively patchy and irregular manner. The loose association of the fibres and the manner of their disposition allows them more uncontrolled movement at this point than at any subsequent point; it is therefore very necessary that the drafting action be a gentle one if good results are to be obtained. The usual practice of increasing the draft at subsequent drawing points, apart from considerations of the weight of the material, is quite sound, as the degree of parallelism and consequent fibre control is correspondingly improved.

The total draft in the first head of drawing should always be as low as is consistent with a balanced and economical output, and it may be possible, from the point of view of parallelism and uniformity, to obtain better results with a draft which is lower than is usual—correction for balanced output and desired count being made in the later machines.

Since parallelism of the fibres is the first necessary step in the formation of a well-drawn and regular sliver the first head of drawing functions more particularly in this respect than the following heads, and as a moderately high degree of parallelism is obtained in the first machine this can be regarded as its chief effect. With this object fairly satisfactorily attained the subsequent machines operate more particularly as regularising agencies. Careful investigation into the precise value of the parallelising and regularising influence at every drafting point in the complete operation may reveal the desirability of some modification of the usual arrangement of drafts, settings, or speeds, and it is probable that, considering the condition of the fibres passing to the first head of drawing, it may be advisable to vary drafts, settings, or speeds, from those existing in subsequent heads. Uniformity in drafts, doublings, and roller settings may be desirable, but the efficiency of the process as a whole is of more importance than rigid adherence to similar doublings, drafts, settings, or even speeds, in all the machines.

Any difficulties in the way of the efficient functioning of the

rollers arising from the feeding of the material in sliver form into the drawing frame should be minimised as far as possible by the formation of a sliver of suitable thickness, according to weight, and the maintenance of the spacing of the slivers, so that they combine into a sheet with the highest possible degree of uniformity in width and density. It is doubtful if in a drawing frame any advantage accrues from having a traverse of more than the pitch of the slivers, for anything in excess of this offers little advantage from the point of view of the wear and tear of rollers, whilst increasing the danger of torn web selvages at the front, which is evidence of the displacement of the fibres and possible irregularity.

### UNIFORMITY

Uniformity or regularity in the thickness and weight of the sliver is one of the chief objects sought in the drawing process. It is essential that the material as delivered from the drawing frames shall have the highest possible degree of uniformity, for the drawn sliver is the foundation from which the yarn is formed. As every subsequent machine is intended primarily to attenuate the material to an appreciable extent so as to reduce it to the count required, any irregularity remaining in the drawn sliver will have a detrimental effect on the uniformity of the yarn.

The means employed to obtain uniformity in the draw frame is the repeated doubling of a number of slivers together at the several machines so as to average out irregularity. This repeated folding must, for obvious reasons, be accompanied by drafting to keep the delivered sliver weight within suitable limits.

As drafting must accompany doubling in the drawing frames, and parallelism amongst the fibres is necessary for efficient drafting, it is necessary for ultimate uniformity. A set of drawing frames, considering their action as a whole, function in the initial stage at the maximum as a parallelising agent and at the minimum as a uniforming agent, the former effect decreasing as the latter increases, until at the later stages the uniforming effect is at a maximum and the parallelising action at a minimum. For this reason, and as previously

stated, there seem important reasons why considerably less draft may be exerted with advantage in the first machine than in the last one.

A high degree of uniformity in count, as revealed by the usual test, can be expected as a result of all the folding which occurs in the drawing frame, and it is probable that, if the general machine conditions are normal and the drafting action is efficiently performed, a satisfactory degree of uniformity in thickness and weight along the whole length of the sliver will be attained. Entirely satisfactory results are therefore largely dependent upon efficient drafting, as, without it, the continuous uniforming effect of doubling is being nullified to an excessive degree as it operates.

If perfect drafting is the drawing forward of fibres of equal length and thickness in succession at regular intervals, then it can only be attained if all the fibres are of equal length and thickness, and the strand is of maximum uniformity in thickness along its length. Since these conditions are impracticable, the irregularity which is inevitably produced by drafting can only be averaged out by doubling, the former tending to create and the latter tending to neutralise irregularity.

The maximum degree of uniformity is obtained when drafting merely elongates the strand, reproducing the standard of uniformity as originally present, without producing fresh irregularity. This may only be obtained when each fibre is under the definite control of the drafting arrangement, which should therefore be set to obtain control of the maximum number of fibres as they pass forward under drafting action. The best setting can only be ascertained when all the conditions are known, but its determination is a matter of the greatest importance. The presence of fibres under treatment which are too short to be effectively controlled is the greatest disturbing factor in drafting, and the degree of irregularity produced will, in a great measure, be affected by their number and character.

As uniformity is one of the objects of the drawing process, it is necessary to avoid the possibility of irregularity being produced as the material is withdrawn from, and deposited in, the sliver can. It must be realised that the sliver is weak and easily stretched, and,

should stretching occur, serious effects in the regularity of the finished sliver will result, particularly if occurring in the last machine of the set. The cohesion amongst the fibres and the strength of the sliver is reduced as parallelism increases, so that there is more likelihood of stretching with combed than with carded slivers of equal weight. As fibre parallelism in carded slivers increases as the material passes through the drawing process, the tendency to stretch is greatest at the last machine in the set and at the back of the slubbing frame. On the other hand, owing to the parallelising effect of combing, and the manner in which the sliver is formed by successive overlaps, combed sliver is much weaker than carded sliver as it passes to the first head of drawing. The combed sliver, however, may gain in strength in the early stage of the drawing process, as a result of the folding and the better amalgamation of the material which occurs, but subsequently becomes weaker, before the drawing operation is completed, as a result of repeated drafting.

It is advisable to employ spring-bottom cans at every point for combed slivers, as the tension of withdrawing them from the can is liable to cause stretching. The use of such cans for carded slivers may be unnecessary except when the slivers are very light. In all cases it is necessary to keep cans in good condition since any which are out of shape will cause bad coiling, resulting in disordered and stretched slivers. The rims of the cans should be smooth and well rounded off to avoid damaging the sliver as it is withdrawn, and the coiler speed should be such that the coils, after being laid in the can, shall not be displaced. The speed of the can plate should be regulated so that the coils may build up neatly and be withdrawn without displacement of adjacent coils. The use of assisting rollers at the back of each drawing machine, whether the electric stop motion is applied or not, is to be recommended under nearly all conditions, as is also the use of the assisting roller at the slubbing frame when combed or light slivers are being dealt with, to reduce the strain on the sliver and the possibility of stretching.

Whilst dealing with the question of uniformity, reference may be made to the means usually employed for determining the degree of uniformity attained in the drawing frame.

The ordinary mill methods of testing slivers cannot be regarded as adequate tests for linear irregularity, such tests will indicate the count and will reveal some types of irregularity whilst other types will remain undisclosed. It is difficult, for example, to imagine how any considerable variation in count—as revealed by the usual test—can remain after the drawing process, considering the enormous amount of doubling that takes place, if a reasonable degree of drafting efficiency occurs in the operation, yet the same material may have obvious and serious inherent defects.

Testing for count and linear irregularity are essentially different, material may be quite satisfactory in the former respect but very unsatisfactory in the latter. Simple and adequate means of testing for linear irregularity in addition to count, not only at the yarn stage but at some of the preceding stages, would be highly valuable. A knowledge of the thickness irregularity which occurs at the various machines is necessary in the control and reduction of the same. In connection with this, much careful investigation into the irregularities of various machine products has been carried out by the British Cotton Industry Research Association, and their findings are very interesting and of great value.

## CHAPTER V

### DRAFTING : EFFECT OF TWIST AND DOUBLE ROVING

#### DRAFTING : TWIST IN MATERIAL

THE conditions under which drafting action is exerted when the fibres are slightly bound together by twist are essentially different from those existing when it is exerted on an untwisted strand. The reduction in thickness occurring in the flyer frames makes it necessary to insert a small amount of twist, so that the material can be dealt with satisfactorily.

The two main considerations involved in determining the amount of twist inserted in the roving are the amount necessary for successful winding on and unwinding from the bobbin, and the amount which will give the best results in the subsequent drafting operation. The former consideration is usually regarded as being the determining factor in the amount of twist required, and therefore becomes the determining factor in length output. Any extra twist above the minimum necessary on this account will, therefore, necessitate the making of a coarser hank, so as to obtain the necessary production, and impose the necessity of higher draft at other points.

The general statement that the amount of twist put into a roving should be just sufficient for satisfactory winding on and off the bobbin is essentially correct. The statement, however, involves more than the obvious implication, for consideration will show that the whole of the conditions about the machines are factors in determining the satisfactory minimum of twist for this purpose. It is therefore important that the general conditions in the machine shall allow the minimum amount of twist, since the amount necessary for satisfactory winding on and off the bobbin is generally more than is desirable for the best drafting conditions.

The essential difference between an untwisted and a twisted strand, from the point of view of drafting, is that in the former the fibres are laid parallel lengthwise in the strand and are only very loosely associated, whilst in the latter they are bound together in a spiral manner by the twist inserted. The amount of mutual pressure set up amongst the fibres in a twisted strand will depend to a large extent on the amount of twist, the thickness of the material, and the length and general character of the cotton.

Twist has the effect of restraining radial and lateral movement of the fibres in the strand, and when present to a satisfactory degree is beneficial to the process of drafting, by preventing the fibres from spreading and getting out of effective contact with each other, and by exerting a slight retarding influence on the forward movement of the fibres as they are subjected to drafting action.

Longer fibres, on account of their length, will be more effectively bound in the strand than shorter fibres, and because of their greater flexibility the finer fibres will be better bound together than coarser fibres, if the twist and other conditions are similar. Cotton which is very irregular in length and other features will require more twist, that is, a higher twist constant, to obtain the necessary degree of cohesion than that which is more uniform in these features.

The factors, however, which affect the necessary cohesion amongst the fibres to obtain the required strength for winding on or off will up to a point contribute, in uniformly thick material, to the formation of a strand which can be drafted efficiently. The material requiring more twist to give adequate strength will, in general, require more twist for efficient drafting, but the amount of twist, or the twist constant, necessary to obtain the most efficiently formed strand for drafting purposes is small. The extra amount of twist necessary for satisfactory winding on and off in excess of efficient drafting requirements varies with the quality and weight of the material, but its amount must be considered in relation to such factors as break draft and the character of the control immediately preceding the front line of drawing rollers in the next machine, and is a matter of greater importance under high drafting than under normal drafting conditions.

Increased irregularity in the thickness of the material will, in these machines as at subsequent points, require an increase in the amount of twist necessary for strength, and will also result in increased irregularity in its distribution. The thinner portions will become the harder twisted portions and cause increased resistance to drawing in the subsequent machine, tending to accentuate the fault already existing.

As the general purpose of twist is to dispose the fibres in an approximately parallel and spiral manner and set up forces which will restrain undesirable radial and lateral movement of the fibres in the strand, its beneficial effect should be retained, as far as conditions will allow, up to the critical drafting point, so that it can operate in limiting uncontrolled fibre movement. The amount of twist inserted in the material in any machine where subsequent drafting occurs being a matter of importance, it may be profitable to consider some points which affect not only its amount, but its distribution, in so far as they affect the efficiency of the subsequent drafting operation.

The object of the flyer - frame twisting and bobbin - building mechanism is to form the material as it emerges from the front roller into a smooth twisted strand that can be drafted efficiently, and to wind it on a bobbin in such a way that it passes into the next drafting operation without damage. These objects are not always fully achieved, and some of the conditions which prevent their attainment may now be considered.

It is desirable that the twist shall travel as freely as possible to the nip of the front rollers, so that the length of the tape at the front is reduced to a minimum and the tendency to stretch at this point in the strand reduced. The position of the front top roller should be considered in this connection so as to shorten the tape as far as is consistent with efficient drawing conditions. The width of the tape emerging from the front rollers will affect its length and will vary from machine to machine. It will be greatest in the slubbing frame owing to the thickness of the material and its tendency to spread due to the absence of twist. The tendency for excessive width and variation in width of the tape in this machine should be

controlled as far as possible by good design and arrangement of sliver guides.

It is possible that some improvement in this direction could be effected in many cases by the use of a better type of sliver guide, as the horn-shaped guide so commonly used, whatever advantages may be claimed for it in regard to its convenience, is unsatisfactory in some respects. Its fault, as ordinarily constructed, is that, owing to its width and shape, it allows undesirable movement of the sliver and permits it to pass through at varying widths, thus reducing the efficiency of the traverse motion and of drafting conditions. A type of traverse guide which will minimise these defects is the funnel-shaped guide, which tapers down to a hole from  $\frac{5}{16}$  to  $\frac{5}{32}$  inch in diameter according to the thickness of the sliver and the general conditions. Although this type of guide may in some cases be regarded as inconvenient, it certainly has some considerable advantages over the old type. It compresses the sliver to reasonable and uniform bulk as it passes into the back rollers, giving a narrower and more uniform width of tape at the front. As a result the twist will travel more freely and get closer to the roller nip, reducing the tendency to stretch, and producing a rounder and smoother strand which will improve winding and bobbin-building and subsequent drafting conditions. This type of guide also ensures more uniform traversing speed of material with consequent reduction in the detrimental effect of channelling of covered rollers, and by preventing the passage of thick piecings or other thick places ultimately leads to the reduction in the number of such faults. The funnel guide should have a hole of suitable size and be set at such a distance from the rollers that no interference occurs with the free passage of the material, and no drafting action is set up between the funnel and the back rollers.

The tendency of the material to spread in the drawing rollers of the subsequent flyer frames is reduced by the binding effect of the twist present in the material. It is necessary, however, in these machines, since the usual practice is to double at the back of the rollers, that the roving guides should keep the two ends as close together as possible, providing they do not override each other, so that the tape at the front is maintained at minimum width. This

will assist in the formation of a smooth round strand as free as possible from the surface roughness which is so detrimental to the building of a good bobbin and subsequent unwinding and drafting.

The tendency for the material to stretch as a result of tension between the rollers and the flyer top is difficult to avoid. It is more likely to occur in the slubbing frame than in the subsequent speed frames, on account of the thick and soft nature of the material, and more likely to occur in the front than in the back line in any machine. The extra tension and increased tendency to stretch on the front line are due chiefly to the increased length and weight of the material and the greater number of alternations of tension to which it is subjected in passing forward. The possibility of stretching is further accentuated by the fact that the material passing to the front line is subjected to more severe variations of tension from the rotation of the flyer, and, because of the increased resistance occurring, the amount of twist present in the material passing to the front line may be less than that in the material passing to the back line.

These conditions indicate that, in general, some stretching is probable, and general mill testing confirms this. The finer wrappings which are frequently obtained from the front line of bobbins cannot be accepted altogether as evidence merely of *fineness* due to difference in twisting and tension conditions; they are more probably evidence of stretching, which must be avoided or reduced to a minimum if the best possible results are to be obtained. The tendency to stretch during twisting and winding on is probably least in the last flyer frame, where under good conditions it may be negligible, but in the preceding machines, particularly the slubbing frame, it may be a factor operating continuously against the production of uniform material.

Satisfactory winding-on speed throughout the set and a well-built bobbin, involving correct bottom-cone speed, correct size of lifter and star wheel, good design and finish of flyers, and satisfactory spindle speed, are important factors in the production of good rovings and uniform yarn.

## DRAFTING : DOUBLE ROVING

The normal difference between a yarn made from double roving and one made from single roving is the reduced degree of irregularity in the thickness and related features of the double roving yarn, as a result of the averaging out of the irregularities in the separate strands when combined together.

Whilst admitting the general statement that doubling is beneficial in the way indicated, it is necessary to guard against over-emphasising the beneficial effects of doubling.

As doubling can only be beneficial when irregularities exist, their frequency and degree are factors to be considered. The degree of uniformity obtained in doubled material, after allowing for the averaging-out effect of folding, will be directly related to the degree of uniformity in the separate strands, and it is necessary to remember that the mere process of folding can never, except by chance, entirely obliterate original irregularity. A fault of this character, particularly if arising after the drawing process, will in all probability remain to an appreciable degree to the end; it may be reduced, but it is erroneous to assume that doubling can entirely eliminate it.

Irregularity is generally produced either by tension on the strand as a whole, or by drafting action. Irregularity which results from drafting does not necessarily affect the count and is usually of the type in which a thin place in the strand is succeeded immediately by a thick place, the distance between the thin and thick places being comparatively short.

Irregularity produced by tension on the strand will make the count finer, its character and the intervals at which it occurs will depend upon the cause, and its effect on the yarn on its original character and the remoteness or otherwise of the source of the fault. Such faults when produced in the drawing frame will occur at longer intervals at the yarn stage, owing to the considerable amount of draft exercised in the intervening processes, than when produced in the roving frame. They will, however, be reduced by the repeated doubling occurring; whilst the same fault produced in

the later machines will affect shorter lengths, but will retain to a greater extent its original character. For example, a thin, stretched place in the drawn sliver, which is 1 inch long, will be drawn on medium counts to a length of 700 to 1000 inches, the final irregularity being normally reduced to 25 per cent. of the original amount; whilst a length of 1 inch of thin material, from the last roving stage, would be drawn out to a length relative to the amount of draft in the spinning machine, and the degree of irregularity would remain unaltered, if no doubling occurred.

The production of such thin places in a roving is a matter which is related to the question of general efficiency, apart from drafting, in every machine, and the extent to which final irregularity may be affected by remote and somewhat obscure faults of this type created in the drawing or flyer frames is not always realised.

It is necessary to appreciate the difference between stretching and drafting; stretching causes the collective displacement of a mass of fibres, and results in a more serious departure from the normal flow of fibres at the subsequent drafting point than that caused by drafting irregularity. In relation to ultimate uniformity this type of fault has two aspects: it is most likely to occur in the slubbing frame owing to the soft and thick character of the material and the twisting and winding conditions, but the beneficial effect of doubling in subsequent machines is operative; whilst in the last of the roving processes, though the liability to stretching is normally diminished, the averaging-out influence is reduced to one doubling, or absent altogether.

In addition to the advantages already referred to, which arise when doubling occurs, the conditions under which the separate strands are drawn are better than those existing when the whole of the fibres are formed into one strand. Such wide variations exist in practice in regard to the relative weight of single and double roving for a similar count of yarn, due to economic and other considerations, that for comparative purposes some definite conditions are assumed, comparison being made between single and double roving with similar draft when a similar count is produced. The double roving being only half the weight of the single roving, the fibres

will be laid better in the strand, reducing the tendency of the fibres to spread.

The probability of a thin place resulting from drafting action in either of the two finer rovings may be much less than in the case of the coarser single roving, as with the coarser roving the material is under less satisfactory control. Apart from any consideration of cotton quality, weight of material, and the amount of twist, the control on the fibres exercised by the rollers will be more efficient when double roving is dealt with, since there are two separate points of control and pressure.

The front roller will also grip the fibres more satisfactorily and the roller can be set closer with safety, thus giving better drawing conditions in every way. It is necessary, however, to remember that the advantages of doubling are being neutralised to an increasing extent as the draft is increased, and that a point will be reached when, either from considerations of cost on the one hand, or yarn quality on the other, the practice becomes uneconomical. The amount of draft which it is advisable to employ with any class of cotton is certainly related to the weight of the material. The satisfactory draft for a three-hank can be exceeded with safety if the same material is prepared to five-hank roving. The ratio of satisfactory drafts between a coarser and a finer hank is, however, difficult to indicate and is largely a matter for investigation under any particular set of conditions.

When drawing from double roving, the arrangement and type of traverse guide should be such as to ensure that the separate ends are kept close together in passing through the rollers; if they are allowed to separate, they emerge from the front rollers as a tape, the passage of twist to the nip of the rollers is impeded, the liability to stretching and breakage is increased, and the material produced will be less satisfactory in every way.

## CHAPTER VI

### THE SETTING OF DRAFTING ROLLERS

THE setting of the ordinary type of drawing rollers is normally regarded as the distance between the nip of two successive pairs, the nip of a pair of rollers being usually defined as the point of contact. This definition of nip requires modification on account of the character of the roller surfaces; some modification being necessary on account of the longitudinal fluting of the bottom roller and, where such are employed, of the flexible character of the top-roller surface. Under the pressure exerted the surface of a flexible roller yields and maintains contact with the bottom one over a breadth of bottom-roller surface which will vary according to circumstances. The breadth of this contact will be affected by the weight applied, the flexibility of the roller, and the diameter of the rollers in contact. Any increase in the flexibility of the roller surface or in the pressure applied, as well as any increase in the diameter of either top or bottom roller, will result in greater contact breadth.

That the nip of such rollers has breadth can be readily demonstrated by obtaining a carbon impression of contact surface. Under normal conditions this will show that, in a spinning machine, top and bottom front rollers of 1 inch diameter are in contact over a breadth of almost  $\frac{1}{8}$  inch. Although it may not be correct to regard the contact as being uniformly effective over the full breadth of the impression, it is a factor operating in determining the setting distance between drafting points. Reference to fig. 2, which represents weighted roller conditions in a spinning machine, will indicate that the rollers have reasonably good control of the material over an appreciable length, which must be considered in relation to fibre control

during drafting, particularly in its effect on the control of those fibres which are shorter than setting distance.

It can be assumed that under medium counts conditions with five-hank roving both the middle and front rollers will exercise

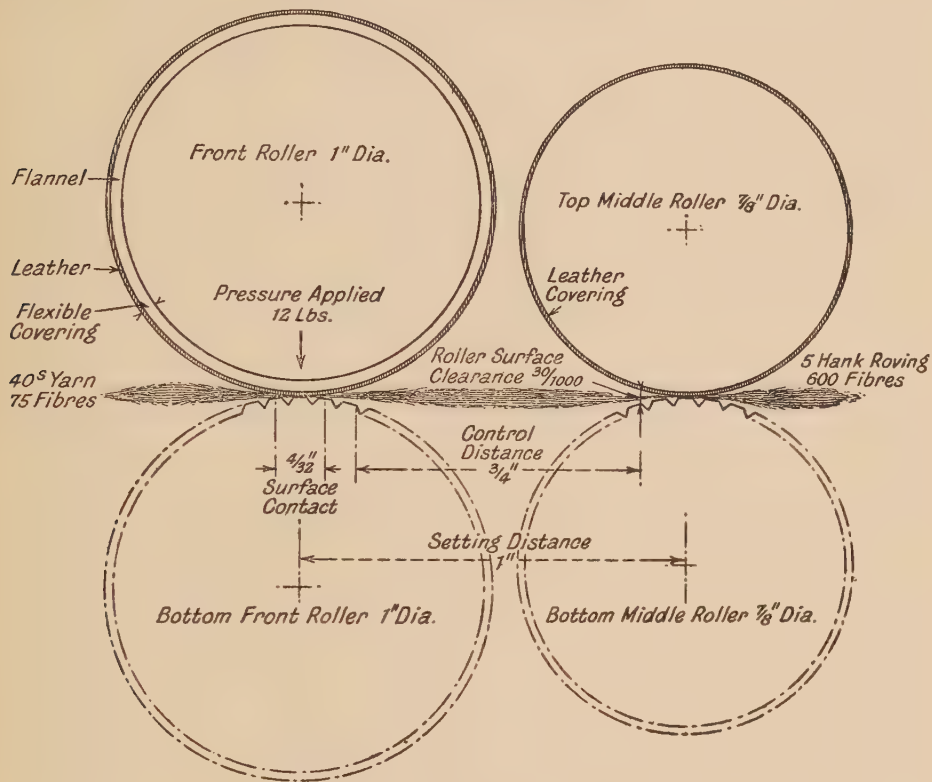


FIG. 2.—NIP OF DRAFTING ROLLERS.

some controlling influence over the material to the point where the clearance of bottom and top rollers does not exceed  $\frac{3}{100}$  inch, and exert in the former case a retarding force, and in the latter a pulling force on the fibres. Under the conditions indicated in fig. 2, the middle rollers will be confining approximately 600 fibres in a space, vertically, if not horizontally, which is only about twice that of the diameter of a twisted yarn of similar weight, and will be exercising some restraining force over the individual fibres. The front pair of rollers will also be exerting some controlling influence

on the fibres at the point of equal clearance, due to the fact that approximately 75 fibres are moving forward in a confined space at the surface speed of the front rollers. It is therefore not unreasonable to assume that, under such conditions, the actual control distance, as shown in the diagram, may be approximately  $\frac{1}{4}$  inch less than the setting distance, and that, after making allowance for relaxation of fibre tension between control points, all fibres which slightly exceed control length will be drawn fairly satisfactorily.

The breadth of roller contact surface is a matter for consideration in a further respect; for any increased breadth, with equal contact pressure, will increase the effectiveness of the control exercised on the material and establish better drafting conditions.

The surface character of a roller materially affects setting distance, for the substitution of a bare metal roller for a leather-covered one of similar diameter will require closer setting on account of the diminished breadth of contact surface and reduced effectiveness of fibre control. There are some advantages accruing from the use of bare top rollers at some points, owing to the elimination of covering costs and reduced liability to damage, but it is doubtful whether their use is in many cases justified.

The setting between the drafting points in the various machines is a matter of the greatest possible importance, as upon it depends in a large measure the regularity of the drafting. The determination of these settings involves an appreciation of many factors, such as staple length, irregularity in length, fibre thickness, thickness of material, amount of draft, effect of twist in material, and, within certain limits, the speed of drawing, as well as such other factors as the tension in front of the delivery rollers and the condition of the rollers. Some effects of these various factors on settings may be considered.

*Staple Length.*—There is an approximate relation between the staple length and roller setting, but the relation is somewhat indefinite. Staple length indicates the length factor of cotton, but it conveys no very definite indication of the degree and amount of variation in length, both of which are important factors in roller setting; it is therefore almost impossible to definitely relate staple length with setting distance.

When drawing rollers are regarded as definitely weighted, it is usual to set them approximately equal to, or outside, staple length. The distance that setting exceeds staple length under such conditions will vary in the different drafting stages according to the thickness of the material. In the spinning machine, the setting being approximately equal to staple length, it follows that there will always be a small, though varying, number of longer fibres which will exceed the setting distance. It does not follow, however, that, if there are a few such fibres present, the drafting will be detrimentally affected, or that there will be any broken fibres, as the hold exercised by definitely weighted rollers in a spinning machine will allow a few fibres to be drawn through the nip of the middle line. The number of fibres held in tension and gripped between the nip of the front and middle rollers in the spinning machine, with roller setting equal to staple length, will only be small, and probably much less than might appear. For example, in the case of a roving containing 600 fibres, if 5 per cent. of this number extend from beyond the nip of the front to beyond the nip of the middle line, less than 4 fibres, with a draft of eight, will be subject to the maximum control exercised by both lines of rollers. It is highly improbable that so few fibres, being much more firmly gripped by the front than by the middle line of rollers, will resist to the extent of interfering with drafting in any appreciable way.

If, however, conditions in the roving frame are considered, the number of fibres delivered would be 600, 30 of which, as compared with 4, would considerably exceed the normal roller-setting distance in the spinning machine. It is obvious that the possibility of drawing through being retarded by 30 fibres would be greatly, if not relatively, increased; hence, the roller settings in the roving frame, on this account, must be wider than in the spinning machine so as to reduce their number if interference with drawing is to be avoided. The same influences will operate in the intermediate and slubbing frames, and affect roller setting according to the number of fibres fed and delivered. Any increase in the bulk of the material as well as any increase in the relative number of long fibres present will always require wider roller setting.

When determining roller setting, since cotton is always irregular in length, the staple length and irregularity must be considered together. The effect of these two factors may be considered by reference to fig. 3, which is shown as representing, diagrammatically, the length feature of three cottons with varying degrees of irregularity but of similar staple length. Assuming No. 1 to be of average irregularity, No. 2 less irregular, and No. 3 more irregular than No. 1. For the purposes of comparison, and for the reasons advanced, it may be

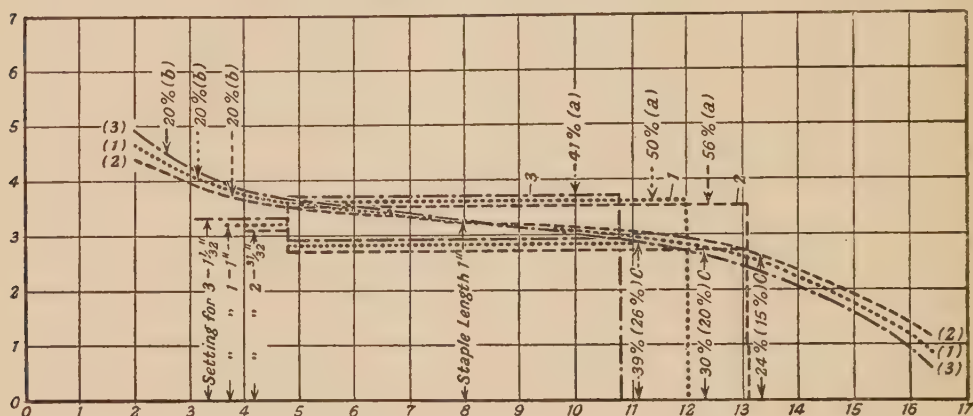


FIG. 3.—STAPLE IRREGULARITY AND ROLLER SETTING.

assumed that, if the roller settings are equal to staple length, all fibres which vary by no more than  $\frac{1}{8}$  inch from staple length will be drawn freely and satisfactorily. These fibres may be referred to as (a), normal length fibres; those above this length as (b); those below as (c). The diagram shows that No. 1 has 20 per cent. of (b) and 30 per cent. of (c). With regard to (b), which for length exceeds setting distance, the number of such fibres which may be damaged or interfere with drawing is probably more apparent than real for several reasons.

It may be taken for granted that, as the fibres are passing from one line of rollers to the next, the tension on the individual fibres is relaxed in some indefinite measure owing to the springy nature of the material, and that upon being gripped by the succeeding line some straightening out of the fibre occurs. It is probable also that

a very definite pull on any fibre is not established until a short length has passed between the nip of the front line of rollers, as the grip of the rollers on a mass of fibres is a general one, and though individual circumstances will vary widely, the grip on any individual fibre is somewhat indefinite when it first passes under the roller. The instant when effective drawing control is established on any individual fibre is also affected by the movement and character of the fibres with which it is associated.

In practice, however, it is certain that, in almost all circumstances, an appreciable percentage of the fibres, varying according to conditions, and in the present case assumed to be 20 per cent., which are longer than setting distance, will pass forward quite satisfactorily. The fibres of normal length (*a*) will be easily and satisfactorily drafted and will have a very beneficial influence in acting as carriers or controllers of the shorter fibres (*c*) as they are passing forward. The percentage of (*a*) influences considerably the regularity of the drawing of the whole material in this way, and, to a considerable extent, the uniformity of the finished yarn. The higher the percentage of this class the more satisfactorily will the drawing be performed, as they are drafted regularly and act beneficially in controlling the shorter fibres.

The short fibres (*c*) are mainly the troublesome element, as most of them are released from the control of the second line of rollers before they come definitely under the control of the front line. The erratic movement of these inadequately controlled fibres, resulting in their irregular distribution and position, is due to several disturbing influences. Some of the longer fibres which are associated with them are being definitely drawn forward under tension at a much higher speed by the front roller, whilst others are only moving forward under little tension at middle-roller speed—the two influences being present in increasing and diminishing degree as the material passes forward. The effect of these influences is to displace the short fibres, to force them to the outside of the strand and carry them forward irregularly, ultimately affecting the uniformity and oozyiness of the yarn. It is evident that the regularity of a yarn and its general appearance will be greatly influenced, not only by the number of fibres classed as (*c*), but by the variability in length of such fibres.

Under definitely weighted roller conditions the setting distance must be such that the number of fibres extended in tension between two successive pairs of drawing rollers shall in no case be sufficient to impede drafting. These conditions may be taken as a basis for further consideration of roller setting in the spinning machine under the conditions named.

The graph No. 1, fig. 3, represents the variation in length of the average cotton, the area outlined enclosing the fibres which vary no more than  $\frac{1}{8}$  inch from setting distance. The fibres within this area which are classed as (a) amount to 50 per cent. of the total number; (b) those above amount to 20 per cent., and those below to 30 per cent. For the reasons before stated it is assumed that (b) will set up no material disturbing influence in drawing, (c) being the chief element in producing unsatisfactory drawing and irregular yarn.

The graph No. 2 in the same figure represents the variation in length of the most uniform cotton which has a higher percentage of its total number of fibres within the range of good drawing, that is,  $\frac{1}{8}$  inch above and below setting distance. The number of such fibres is enclosed in the area outlined as (2) and amounts to 56 per cent. of the total, leaving 20 per cent. above and about 24 per cent. below. The area enclosing the 56 per cent. is set lower than that representing the length control area of No. 1, indicating closer setting; it, however, only leaves the same number of longer fibres above the area whilst reducing the number of short ones below very considerably.

The diagram also indicates the improbability of any detrimental effect arising from the closer roller setting on the more uniform cotton, as there is no increase in the number of long fibres above the area, whilst the number of short ones below is considerably reduced. The closer setting possible with No. 2 has reduced the disturbing element considerably, and any roller setting wider than that indicated would fail to secure the best results.

The graph No. 3 represents the most irregular cotton, and to ensure that no more than 20 per cent. of the fibres shall be above the normal control area it has been raised, indicating wider roller setting. This will increase the number of fibres below the effective control length, which in this case is approximately 39 per cent.,

leaving only 41 per cent. under satisfactory control. The diagram illustrates the effect of variation in fibre length on setting distance and indicates the effect of both on drafting.

Figure 3 and the particulars already given relative to it do not quite represent all the advantages to be gained by the use of the most uniform cotton, for, although the 20 per cent. excess length margin is observed in all cases, the excess length of this number in No. 2 is less than in either of the other two cottons. The result will be that the danger of interference with drawing is actually less than normal, and might allow even closer setting than that indicated and still further reduce the number of the short fibres below effective control length. In the cotton represented by (3), although the setting distance has been increased to keep within the 20 per cent. limit of long fibres, the variation in length of them is greater than normal, involving a corresponding increase in the danger of interference with drawing. The 20 per cent. of fibres outside setting length may be regarded therefore only as an approximation, the actual percentage varying with the degree of irregularity in the material.

The effect of class (c) on fibre loss in drafting may now be referred to, and further consideration paid to their effect on uniformity. The approximate percentage weight of these shorter fibres is shown in fig. 3, No. 1 (c), 20 per cent.; No. 2 (c), 15 per cent.; No. 3 (c), 26 per cent. In addition to containing the greatest percentage of short fibre—and here it is important to note that short fibre, from the point of view of drafting, is not definitely related to actual length, but to the relation between actual length and setting distance—the most irregular cotton contains in this class fibres of more variable length, involving more loss in the drafting operation than any other. This will increase the number of yarn faults, as the roller beams and all adjacent parts of the machine will be dirtier and the general conditions less satisfactory.

To illustrate the effect of the drafting of short fibres on irregularity it is assumed that a 40's yarn is being produced from single roving with a draft of eight, the cottons Nos. 2 and 3 (fig. 3) being used for comparison, the rollers being set as indicated. As it is only possible to draft efficiently when the fibres are adequately controlled, the 15 per cent. and 26 per cent. of total weight will not be properly drafted,

but will be carried along in an irregular manner and in more or less detached groups. In the more regular cotton with 15 per cent. of short fibres, if the draft of eight is efficiently performed on the remainder, the short ones, if carried along in more or less undrawn and detached clusters, may be, at such points in the drawn material where they occur, equal in weight to the efficiently drawn material. It is not suggested that the short fibres pass forward in quite detached and undrawn clusters, but that they pass forward in an erratic manner and produce considerable irregularity. The illustration is given merely as a possibility of what may happen rather than what actually occurs, but it is obvious that the amount of short fibre and the manner in which it passes forward will seriously affect results. In drafting No. 3 in which 26 per cent. of total weight is below control length, the possibility of irregularity arising is very much increased, and if the percentage of (*c*) to total weight is taken as a basis, the irregularity arising from this source may be almost double that occurring with No. 2.

As far as is possible lower drafts should be employed on the more irregular cottons, as the reduced draft and the better control arising from the feeding of a finer hank roving will help considerably to minimise the resulting irregularity. A high draft on irregular cotton under definitely weighted roller conditions must inevitably result in an abnormal amount of irregularity.

Roller setting will, apart from the influence of varying degrees of irregularity, closely follow staple length, and will be increased approximately as the staple length increases. There is, however, some difference in the efficiency of fibre control with varying staple lengths, as, although the proportion of the various classes of fibres and the degree of variation may remain the same, the efficiently controlled portion of a longer cotton will draw more satisfactorily than that of a shorter one, and will therefore control more efficiently the erratic movement of the very short fibres.

When combed cottons are drafted the conditions affecting roller setting differ considerably from those existing when uncombed qualities are being dealt with, as a varying amount, if not the whole, of the shorter fibres present in carded qualities is removed in the combing process.

Some of the further points relative to roller setting may now be considered.

*The Thickness of the Material.*—In a slubbing frame producing medium count the material passing through the rollers may be thirty times heavier than that passing through the spinning machine. On account of this the rollers will, apart from their diameter, character, and pressure, exert a controlling influence over a greater breadth than the spinning-machine rollers, and owing to the greater number of fibres held and drawn the setting distance must be greater if drawing is to occur uninterruptedly. For the same reason a three-hank roving will require wider roller setting than a six-hank roving if all other conditions are similar.

*Fibre Thickness.*—Coarser fibred cotton requires wider roller setting than normal cotton. This is necessary on account of the increased resistance set up in drawing the individual fibres through the mass of such fibres, and because the front rollers will obtain a more effective grip on the individual fibres owing to their thickness and related features. In addition the percentage of fibres appreciably exceeding setting distance that may be a safe one with normal cotton, may with cotton of this character interfere with satisfactory drawing.

The introduction of such cotton into a mixing may, for the reasons given, set up interference with drawing, although the length character of the cotton is the same, and necessitates wider roller setting. If this is necessary, the object of its introduction, which is increased yarn strength, may not be attained if it results in less satisfactory drawing of the material as a whole, and care is necessary in the selection and in the proportion of such cotton used in the mixing so as to avoid interference with general drafting efficiency.

*Natural Twist.*—Cotton in which fibre twist is more highly developed and regular will offer greater resistance to drawing than cotton with fewer or less uniform twists, and may require slightly wider setting. It does not follow, however, that more irregular drawing will result from this, as the assembled fibres will, owing to the greater number and increased regularity of fibre twist, have better general control over the movement of each other. They will

also, individually, offer more uniform resistance to drawing than if this feature is less prominent or more irregular, and in this way assist in more regular drawing and the production of more uniform yarn.

*Amount of Draft.*—Roller setting is related to the amount of draft exerted on account of the disturbance set up amongst the fibres. Thus, a draft of ten will, of necessity, have a greater disturbing effect on the fibres than a draft of six, owing to the relatively higher speed at which the fibres are drawn from the mass of fibres with the higher draft, and also on account of the fact that the fibres are under the disturbing influence of drafting action for a longer period. The front drawing rollers, however, having fewer fibres to draw for the finer count with the same roving may be set slightly closer. This is very desirable, as it reduces the increased tendency for irregular drafting arising from increased draft, and reduces the fibre disturbance resulting from the higher draft and the longer period the fibres are subject to drafting action.

*Speed of Drafting.*—If comparison is made between yarns produced under identical conditions other than a considerable difference in drawing roller speed it will be found that, within limits, the lower speed will result in the production of a smoother and more regularly drawn material. In this case the improvement arises from the lower speed at which the drafting takes place, reducing fibre friction and enabling the rollers to exercise better control of the material. The time factor will also affect the character of the control that the rollers exercise, and will have its effect on the disturbance set up amongst the fibres; less disturbance and better control, with reduced fibre friction, occurs within limits with the lower speed, resulting in more uniformly drawn and smoother material.

The effect of drafting speed is also closely associated with fibre electrification. It is highly probable that the increased friction set up amongst the fibres under drafting action with higher roller speeds increases the electrostatic charge present in the fibre with accompanying increase in fibre disturbance, detrimentally affecting the regularity of the drawing and the smoothness of the material.

*Condition of Covered Rollers.*—It is necessary to keep such rollers in very good condition if the best results in drafting are to be obtained;

particularly is this so with very close setting, as the resistance to drawing increases if the setting distance is reduced. The gradual channelling of the front top roller reduces its drawing power, and the drawing of the material may become indefinite, and faulty yarn be produced, if it remains in use too long. The amount of wear which may occur before unsatisfactory drawing takes place is related to the thickness of the material and the setting distance. The excessive rate of channelling of the front top roller, due to inefficient traverse motion, is a matter of importance, and every care should be taken to avoid this, so as to maintain the covered rollers in an efficient condition as long as possible.

*Tension in Front of Delivery Roller.*—This may have some effect on roller setting in the spinning machine, for, if it is indefinite or inconsiderable, wider settings may be necessary than when the tension is greater or less variable. This factor is much more likely to operate in the ring frame than in the mule, owing to the variation of tension continually occurring in the former machine.

The variation in yarn tension in ring spinning, arising from changes in winding-on diameter and the ballooning length of the yarn, is considerable. The difference in tension occurring between the lowest winding-on point, when full diameter of bobbin is first attained, and the highest winding-on point at the end of the set is considerable and may have its effect on roller setting. The setting of rollers in ring spinning is also related indirectly, in some measure, to the strength of the yarn as being the determining factor in traveller tension. Any means that will give more uniformity of tension is of service in this respect ; for example, if the use of lifting thread guides, by reducing the maximum and increasing the minimum tension, will permit the use of a heavier traveller, it will reduce the possibility of interrupted drawing. In the ring frame very close setting or bad drawing rollers are indicated by the occasional formation of crackers in the yarn when the machine is stopping, as a result of the relaxation of tension occurring. Any reduction in tension, whether continuous or intermittent, at the front of the rollers increases the possibility of retarded drawing action, and to avoid its occurrence roller settings must be wider.

## CHAPTER VII

### CONTROL ROLLERS

IN almost all the various high-drafting devices which have been applied provision is made for setting inside staple length, such provision being an essential feature of the arrangements. In those arrangements in which drafting is performed entirely by means of rollers, close setting is possible by the use of a light top or control roller in the second line. This roller performs the most important function in such arrangements, by allowing the longer fibres to be pulled forward whilst at the same time exercising a satisfactory controlling influence over the strand as a whole

Before proceeding to consider high-drafting arrangements and the various types of control rollers, it may be advisable to refer to one or two points relating to the conditions under which drawing rollers may operate. Under the conditions usually existing an uncovered middle or back top roller, even in spinning machines, is not in direct contact with the bottom roller on which it rests and by which it is driven. Such a roller is not driven directly by contact with the bottom one, but by contact with the material between. If the pressure such a roller exerts is inconsiderable, it is more likely to stop and vary in speed than almost any other type, and the control it exercises on the material as a whole is less satisfactory than that of a roller whose surface is less smooth and not so rigid.

If the light control roller has a slightly flexible surface it will, under efficient working conditions, exert more satisfactory control over the material as a whole, and will allow the longer fibres to draw through more satisfactorily than a smooth metal one. It is also, according to its flexibility, the pressure applied, and the thickness

of the roving, more likely to be in contact with the bottom roller than a smooth metal one; and even if not in effective driving contact, it will be more efficiently driven on account of the flexible and frictional character of its surface. The pressure applied by a bare metal roller must be greater than that of a leather-covered one if equally efficient driving control is to be obtained.

As the pressure exerted by the ordinary control roller is applied to the strand as a whole it cannot be uniformly effective on the whole of it, and the efficiency of the control obtained will obviously be affected by the thickness of the material. It is apparent that the control exercised by the ordinary type of roller, under the best conditions of pressure, will be more efficient on a fine roving than on a coarse one, on account of the difference in the thickness of the material. The pressure applied on the roving will cause it to flatten somewhat, the pressure being normally greatest at the centre of the strand. The fibres in the centre will therefore offer greatest resistance to drawing, and as the longer fibres tend under drafting and twisting action to gravitate to this point, they will offer more resistance than the shorter fibres, on account of the greater pressure exerted on them, as well as on account of their greater length.

Other types of ordinary plain rollers, in addition to the two already referred to, are the aluminium roller, the hollow metal roller, and the wooden roller. The wooden roller with steel pivots has been adopted in some cases as being the best from the point of view of cost and general efficiency, and this roller, together with the aluminium and the tube roller, can be made of adequate diameter without being undesirably heavy.

The various types of plain rollers mentioned vary in the effectiveness of the control and driving contact established, according to the character of their surface, so that it is necessary to consider the points raised before concluding that the ordinary solid iron roller is the best type of control roller to use under high-draft conditions.

As it is essential that interruption of the speed of the control roller be avoided, it is necessary that every possible means be employed to reduce friction and the possibility of interference with its rotation by accumulations of waste at the ends of the roller; for

this purpose the roller pivots are sometimes made slightly conical and smaller in diameter than usual.

In addition to the rollers already referred to, any of which may be used as control rollers in high-draft roller arrangements, several special types of control rollers have recently been introduced, to which reference will now be made. The object of these rollers is further to minimise or obviate defects which may arise, under certain conditions, with very close setting. Their special features are usually their surface character and the means employed to obtain satisfactory pressure and freedom from irregularity in pressure and speed.

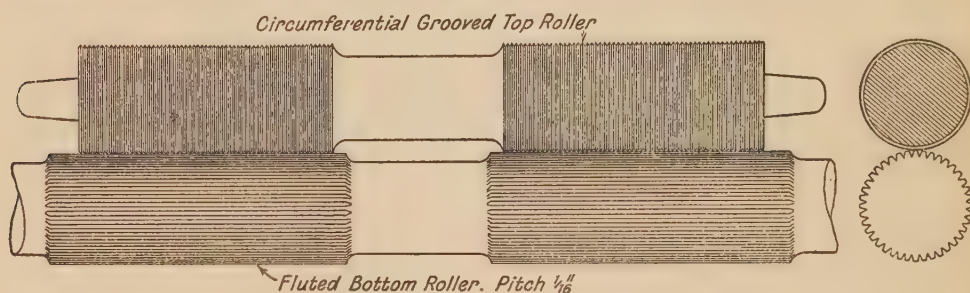


FIG. 4.—V.T.R. ROLLER.

One of these, the Trumbach patent roller, which is shown in fig. 4, has some novel features. It is a steel roller with circumferential grooves cut in the surface, and is employed not only in the spinning machine but in some of the earlier drawing processes. On account of the pressure applied the material passing forward is pressed to some extent into the grooves, thus increasing the amount of surface contact between the material and the roller. As a result of the increased surface contact the roller may be more definitely driven and may exercise a controlling influence over the fibres which is somewhat different in character from that set up by any other type of roller. The penetration of the rings into the material may also result in more uniform spreading of the material as it passes under the roller.

The details of this roller, such as its weight and diameter, and the pitch, shape, and depth of the grooves, are varied according to the thickness and character of the material with which it is intended to deal, so as to obtain the most efficient results.

The extent to which the rings of the roller penetrate into the material will be influenced by the amount of twist it contains, and it is apparent that most penetration will occur when the material is untwisted as at the slubbing frame.

The resistance to the drawing of the longer fibres will also differ from that set up by the usual type of roller, and although it is likely, under proper conditions, to hold the material as a whole quite satisfactorily and allow exceptionally close setting, it is possible that the control exercised on the individual fibres may be more indefinite than that of the usual type of roller, though it may be more uniform throughout the whole.

The amount of penetration occurring will affect the efficiency of the driving of the roller, as increased penetration will, up to a point, increase the amount of friction surface and, providing the weight of the roller rests on the material, will result in increased driving efficiency.

On account of its surface character the weight of the roller may be greater than that of a plain surface roller, thus reducing the risk of irregular movement, and the setting distance may be less without causing interference with the drawing, as the long fibres will draw through more readily owing to the provision of grooves in its surface.

The depth that the rings penetrate into the material will not be necessarily governed by the amount of twist present in the material as it enters the drawing rollers, but by the amount present as it passes under the roller, which may be affected by any drafting action immediately preceding it. On account of this, the action of such a roller may be rather different in an arrangement where a break draft occurs than where no break draft takes place. If a break draft occurs, some of the binding effects of twist may have been released, leaving the fibres in a more loosely associated state.

The possibility of interference with the drawing of the very long fibres by the front line of rollers, with very close setting, as shown in ring spinning by the formation of crackers, is reduced with this type of roller, as the control exercised by it is unlikely to prevent the passage of any fibre, whatever its length or character.

In addition to variation in weight to suit varied conditions, the

diameter of the roller and the depth and pitch of the grooves vary approximately as follows: the diameter from  $\frac{5}{8}$  to  $\frac{7}{8}$  inch, the pitch of the grooves from  $\frac{1}{25}$  to  $\frac{1}{60}$  inch, and the depth of the grooves from  $\frac{1}{30}$  to about  $\frac{1}{100}$  inch. The deeper grooves and the coarser pitch are

employed in those machines in which the material is thicker.

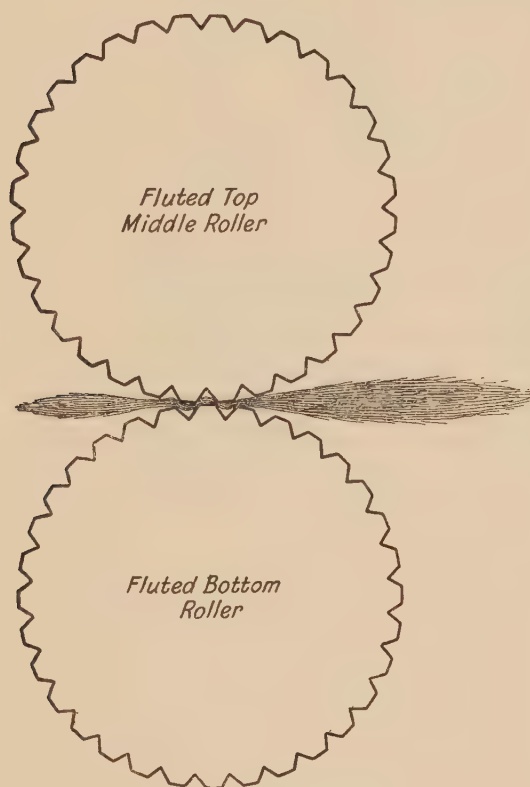


FIG. 5.—FLUTED TOP ROLLER.

Another type of control roller, which is shown in fig. 5, is cut with longitudinal flutes much in the same way as the bottom roller on which it rests. The provision of flutes in the top roller, as in the case of the bottom one, will increase the effectiveness of the contact between material and roller, and increase the definiteness of the driving of the top roller, quite apart from any intermeshing effect between the flutes of the rollers. The possibility of intermeshing of the flutes will be affected by their pitch and shape, and by the thickness of the material; and to the extent such effect occurs will the possibility of irregular

movement of light top roller, which is so serious a fault, be further reduced.

The fluted surface of the roller will also, according to the pitch of the flutes, increase the contact width between roller and material, and in this way increase the efficiency of the control. By increasing the effective driving contact, and by increasing the breadth of contact, this roller appears to have some advantages over the smooth metal one.

This type of roller may be employed as a full-width boss roller, or, in the case of the ring frame, as a separate roller for each strand, in which case a pair may be carried loosely in a patented metal frame, as shown in fig. 6, which fits in the middle roller cap-bar slots, or they may be carried separately by an intermediate cap-bar finger, each roller being free to rest and to rotate independently. It would seem that as a result of the increased definiteness of the grip on the

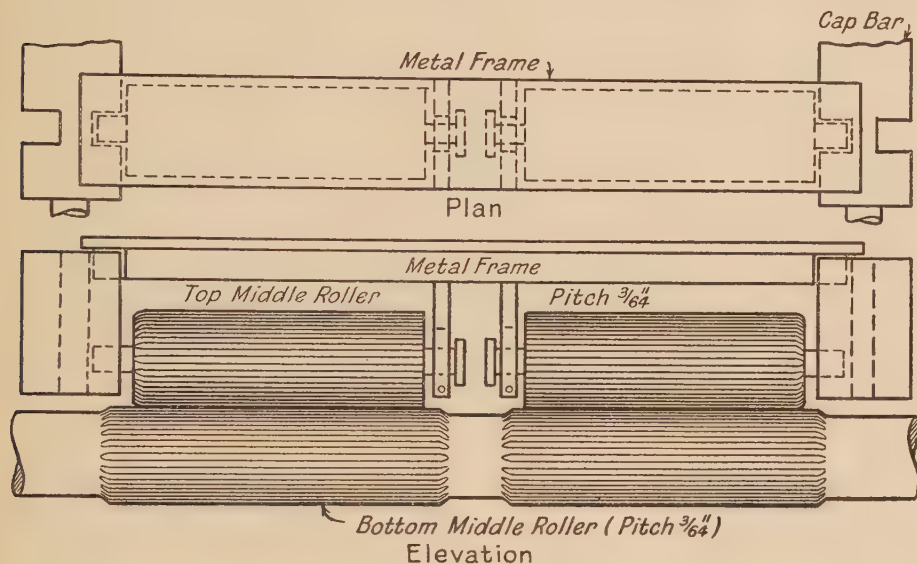


FIG. 6.—SINGLE-END ROLLER HOLDER (ASA LEES).

material, and the improved drawing contact obtained, such a roller would allow a minimum weight and diameter which may be less than that of a smooth surface roller. Any meshing of the flutes will also have its effect on the setting distance, and both will be affected by the amount of twist and the thickness of the material. It is apparent that the pitch and shape of the flutes, as well as the pressure applied, must be related to the thickness of the material and the effect of twist if the best results are to be obtained from the use of a roller of this type.

Another type of patented control roller which has been introduced is the rubber Weco roller shown in fig. 7. When this is employed all rollers may be of normal diameter, the only necessary change being

its substitution for the ordinary top middle roller and, if desired, the setting of the middle bottom roller slightly above normal height, so that the material, as it emerges from the middle line, shall be projected more directly to the nip of the front pair.

The roller has a very thick and highly flexible covering of rubber, sufficient pressure being exerted by means of a weighted saddle to cause the roller surface to flatten out considerably when in contact with the bottom roller. The pressure exerted should be sufficient to control the material as a

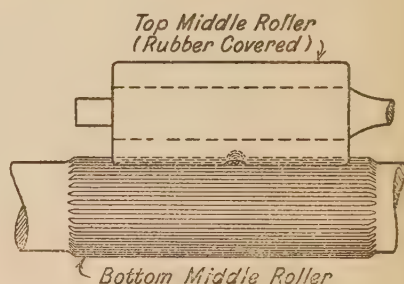
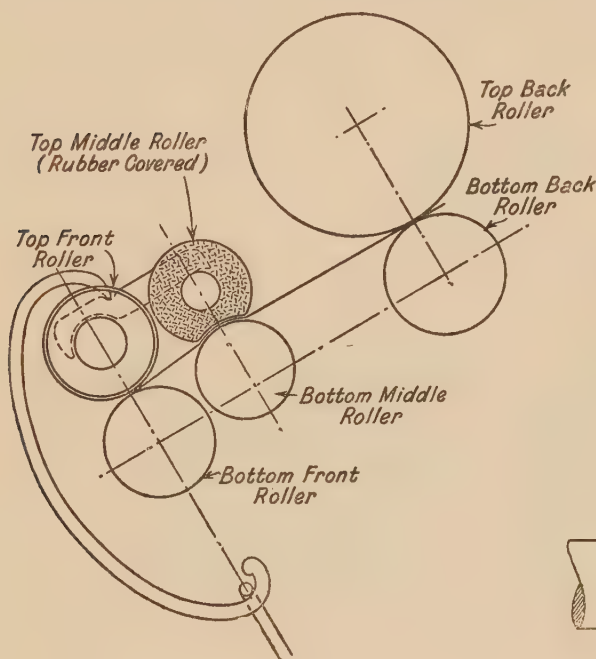


FIG. 7.—WECO RUBBER ROLLER.

whole satisfactorily whilst allowing the individual fibres to move forward as they are seized by the nip of the front pair. The local pressure exerted on the highly flexible surface of the top roller will keep it in contact with the bottom roller for a considerable portion of its surface and exert control over a greater length of the material than the usual type of covered roller.

This greatly extended control zone will have an important effect on setting distance, as the point where the fibres emerge from under the control roller will be very considerably in front of the roller centres. The roller having such a highly flexible surface will be very definitely driven by the bottom roller owing to its broad

contact width and the fact that it will be in direct driving contact with the bottom roller.

The C.S.L. patent top roller illustrated in fig. 8 has some unusual features in the way in which it is driven and in the manner in which control pressure is exerted on the material. It consists of a spindle approximately  $\frac{5}{8}$  inch in diameter at the centre and turned down at the ends, as shown, to allow shells of similar diameter to the centre boss or driving part to fit quite loosely, the shells and centre boss being connected together by a single leather cot drawn over and secured to both. By this means the shells are rotated by the spindle,

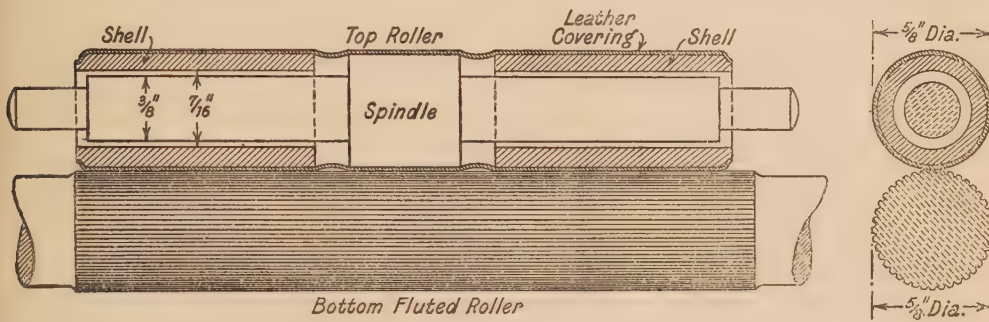


FIG. 8.—C.S.L. ROLLER.

the leather-covered shells resting on the fluted surface of the bottom roller, the flutes of which are cut across the full width. The contact between the fluted bottom roller and the leather-covered boss ensure very definite driving of the top roller spindle, and, as the weight of the spindle does not affect the pressure between the shells and the bottom roller, adequate weight can be obtained for satisfactory driving purposes. By thus disassociating the means of driving the roller from the control pressure one of the chief difficulties associated with light rollers is overcome.

The connection between the shells and spindle being of a flexible nature will permit the shells, within limits, to move eccentrically relative to the axis of the spindle and allow them to rest on the bottom roller, the pressure exerted on the material being due to their weight.

The amount of clearance between the shells and the spindle is

a matter of importance, and, without being excessive, it should be sufficient to allow the shells to work freely and exercise pressure without interference, but at the same time prevent, as far as possible, undesirable eccentricity of movement. The necessity for fluting the bottom roller all across the full width of the top roller to ensure efficient driving of the patent roller may be a slight disadvantage in the removal of bottom roller caps. The roller is, however, a very interesting one, and represents an ingenious attempt to combine definiteness of driving with very slight pressure on the material.

It may now be convenient to refer to a possible source of irregularity in drafting which may arise from the character of the roller surfaces. If a plain top roller with a non-flexible surface rests on a longitudinally fluted bottom roller, the point of maximum pressure exerted on a roving may move slightly backward and forward. The extent to which this may occur will be affected by the pitch and design of the bottom roller fluting, the diameter of the rollers, the angular position of the top roller relative to the bottom one, and other factors. In addition the control of the material such rollers exercise may vary, due to changes in the incidence of pressure, and in the clearance immediately in front of the maximum pressure point.

Although such minute differences in the character of the control and in the setting distance may have little or no appreciable effect under some conditions, they may cause an irregular flow of fibres at the critical drafting point in the spinning machine, where a very high draft is exerted, and be a factor tending to create appreciable irregularity.

It is essential, however, that the diameter and surface character of the bottom roller, and the diameter, mounting, and surface character of the top roller, operating at the drafting point shall be such as to ensure satisfactory general control of the material and otherwise efficient working conditions.

## CHAPTER VIII

### ROLLERS IN PAIRS

#### THREE-LINE SYSTEM

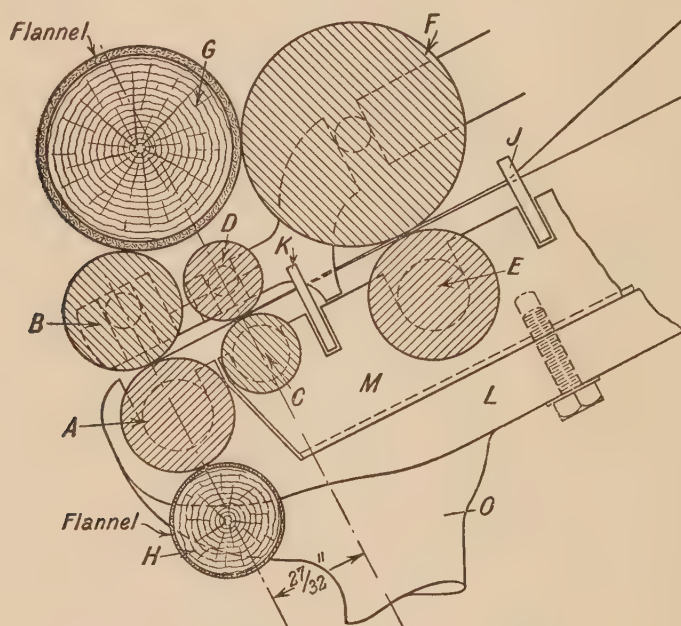
HIGH-DRAFTING conditions are not definitely associated with the amount of draft, but rather with the means employed for drafting purposes. Such conditions are not established by substituting a draft of twelve with a nine-hank double roving for a draft of nine with a six-hank single roving of similar quality. The higher draft in the former case is possible, mainly because the reduced weight of the roving enables the rollers to exercise better control of the material, any improvement in the quality of the yarn being primarily due to this and to the beneficial effects of folding.

What is regarded as the normal draft under any system of drafting will be affected chiefly by the character of the cotton and the weight of the rovings; it will be higher on long cotton and fine roving than on short cotton and coarse roving. Any draft which considerably exceeds the normal draft under any conditions is regarded as a high draft.

The normal draft under high-draft conditions will vary according to the type of arrangement and the character of the material, but will usually be from  $1\frac{1}{2}$  to  $2\frac{1}{2}$  times higher than the normal draft under definitely weighted roller conditions on account of the improved fibre control obtained.

The setting of the ordinary type of spinning-machine rollers inside staple length, with a light top middle roller, a practice which has been in use in the fine spinning trade for many years, establishes what may be rightly regarded as high-drafting conditions, and for the present purpose such conditions are regarded as forming a high-

draft arrangement. This practice, in common with almost all the more recent high-draft arrangements which have been introduced, involves no new principle in the drafting of a strand of cotton, but rather a return to the primitive method of fibre control in the attenuation process.



- A** Fluted Bottom Front Roller 1" Dia. **G** Top Roller Clearer.  
**B** Covered Top " " 1" " **H** Front Bottom Roller Clearer.  
**C** Fluted Bottom Middle "  $\frac{5}{8}$ " " **J** Back Roving Traverse Guide.  
**D** Top Middle Roller  $\frac{5}{8}$ " " **K** Middle Roller Traverse Guide.  
**E** Fluted Bottom Back Roller 1" " **L** Roller Stand.  
**F** Top Back Roller  $1\frac{3}{4}$ " " **M** Middle and Back Roller Slide

FIG. 9.—THREE-LINE ARRANGEMENT.

The development of high drafting on the three-line system abroad has, in recent years, been closely associated with Cesoni-Lirussi, Gilardoni, and Jannick, who respectively took out patents for their arrangements for this purpose.

In considering high-draft arrangements it may be advisable to follow some definite plan, and, because it seems the best method of treatment, they will be dealt with more or less according to the

degree in which they vary from the standard arrangement of three lines of definitely weighted rollers. It is proposed to deal first with the three-line and four-line and other roller arrangements, and subsequently with those in which a single conveyer tape is employed, and finally with the double-tape arrangement.

*Three-line Arrangements.*—Fig. 9 represents an arrangement of rollers which will allow adequately close setting on the longer stapled cotton to give satisfactory control of a high percentage of the fibres drawn, and to allow a reasonably high draft. The fibre-length graph in fig. 10 indicates that, under the conditions shown, the amount of fibre less than setting distance is small, and that in a

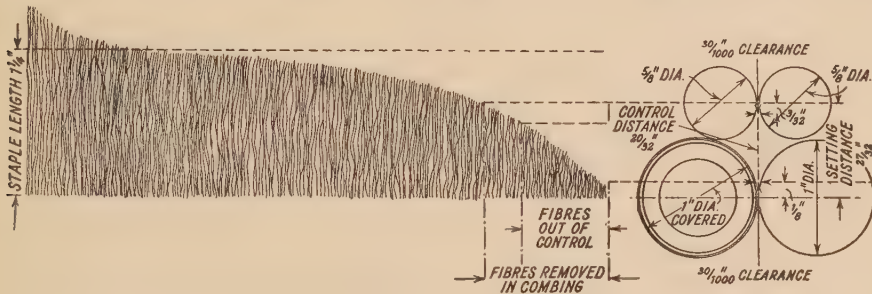


FIG. 10.—ROLLER SETTING AND FIBRE CONTROL DISTANCE.

combed quality, in which all the fibres below a given length have been removed, none of those remaining will be less than minimum setting distance. It does not necessarily follow, however, that when all the material exceeds the minimum setting obtainable the closest possible setting is the best.

Some of the chief factors affecting satisfactory drawing, in addition to roller diameter, are the weight of the roving, the amount of twist, and the amount of draft. The rollers employed should be large enough in diameter to work satisfactorily, and in general the roller diameters given in fig. 9 will give fairly satisfactory results on the class of cotton indicated, although they may be slightly exceeded with advantage if the staple length will permit. Any increase in roller diameter will give steadier turning, more effective control of material, and reduced friction and wear and tear on rollers, besides reducing the tendency to the formation of roller laps.

If the desired setting can be obtained with rollers of satisfactory diameter, the further important factors that require consideration, to ensure most efficient drafting conditions, are those affecting the work of the control roller. These factors—the hank of the roving, the amount of twist, and the amount of draft—may now be considered.

The number of fibres passing under the roller will obviously affect its work if it is to maintain effective control. Assuming that a ten-hank roving contains 50 per cent. more fibres than a fifteen-hank roving, it is clear that a heavier roller will be required on the coarser than the finer roving if it is to exert equally satisfactory pressure, and that the weight of the roller must bear some relation to the weight of the roving.

Another factor relating to the weight of the control roller is the number of fibres drawn from under the roller. The number of such fibres will vary as the hank roving with similar draft, and vary with the draft on a similar hank roving. For example, if a fifteen-hank roving contains 200 fibres on which a draft of fifteen is being exerted, assuming that 75 per cent. of those being drawn by the front rollers are pulled through the middle line, the number of fibres drawn from under the control roller, with double roving, will be 20, whilst in the case of ten-hank roving with similar draft the number would be 30. In the latter case the greater number drawn from under the control roller will have more tendency to interfere with its work than in the former case, and would, apart from other factors, necessitate the use of a heavier roller if interruption to its pressure and speed is to be avoided.

The effect of varying draft on the weight of the roller can be considered by assuming that the fifteen-hank double roving is subjected to drafts of fifteen and ten. As with the lower draft, the number of fibres being drawn from under the control roller will be relatively more than with the higher draft, more resistance to drafting will be set up on the lower draft, with an equal weight of roller, and the tendency to interference with its work increased. In this case, however, the relative fibre movement at the control point must be considered. The lower relative speed at which the fibres are

drawn forward on the lower draft will, in some measure, compensate for the increased disturbance at the drafting point arising from the drawing through of a greater number of fibres, and may render the use of a heavier roller unnecessary.

The effect of the hank roving and the amount of draft on the weight of the roller can, however, scarcely be considered apart from their effect on front roller setting. Where heavier roving or lower draft occurs more fibres are being drawn from under the control roller, but slightly wider roller setting may be employed with little or no influence on drafting conditions, because of the increased controlling influence of the greater number of fibres present under, and emerging from, the middle top roller in the case of the heavier roving, and on account of the reduced fibre friction and disturbance set up during drafting with the lower draft.

The amount of twist in the material is related to the weight of the control roller as well as to setting distance. In relation to the weight of the control roller and roller setting, the amount of twist in the roving does not necessarily refer to the number of turns per inch in the material, but to the binding effect that the twist exerts on the individual fibres. A roving made from long-stapled cotton will, on account of the length and the fineness of the fibre, obtain the cohesion necessary for strength purposes with a low degree of twist-binding force, and allow easy drafting of the material. The looser association of the fibres thus obtained will permit a relatively closer setting under almost any conditions of drafting, but particularly so when a high percentage of the fibres is being drawn from beyond the control point where the twist in the material is more or less undisturbed. The easier manner in which the fibres are drawn from under and beyond the control roller will affect the pressure that the roller must exert as well as the setting distance.

The fineness of the fibre will also affect the weight of the roller and the setting distance, as with otherwise equal conditions the finer fibres will be equally well controlled by a lighter roller on account of their softness and flexibility, and the easier manner in which they draw through will cause less disturbance, thus reducing the tendency for interference with its pressure and speed.

The weight of the control roller and setting distance are intimately related. Any increase in the weight of the roller will necessitate wider setting, as the increased resistance to drafting may set up interference with the regular drawing of the fibres or with the pressure and speed of the control roller. The employment of a control roller of suitable weight, diameter, and surface character for average conditions will, therefore, by judiciously varying setting distance, give fairly satisfactory results over a reasonably wide range of conditions. The actual setting distance can only be determined when all the relevant factors, such as the length and character of material, weight of roving, the amount of twist and draft, and all other factors are known.

With regard to the control roller, it is probable that in the three-line system, unless special provision is made to ensure more definite driving, or the roller is comparatively heavy, a  $\frac{5}{8}$ -inch diameter roller is very near the minimum that can safely be employed. If a roller of the ordinary type of smaller diameter than this is used, its speed and pressure will tend to be more uncertain. A heavier roller of smaller diameter may overcome these tendencies, but its use would necessitate wider setting, and the object of its introduction, which is presumably closer setting, would not be achieved.

Although no really satisfactory attenuation of the material is possible between the middle and back line on account of the character of the control exercised by the middle line, it is generally advisable to run the middle bottom roller at a surface speed 5 to 10 per cent. in excess of that of the back rollers. This reduces the possibility of the roving becoming slack, places the fibres individually under slight tension without displacing them collectively, and delivers them in better condition for the front draft; it may also, according to the character of the roller surfaces, assist in the more efficient functioning of the control roller. It is necessary also that the material shall be kept in tension between the back and middle line, so as to maintain the efficiency of the traverse motion. The difference in speed indicated is not in any sense an attempt to exercise draft, as this is impossible under such conditions, but to ensure more satisfactory control of the material as it passes from the back to the front line.

Middle roller traverse guides are very beneficial when employing double roving, as the two rovings are kept close together and the material well controlled, when under uniform tension, near to where it enters between the middle line. The control at this point is much more efficient than the control at the back, and it is important that it shall be quite definite as the material is passing through the middle and front line, so as to minimise wear on the covered rollers.

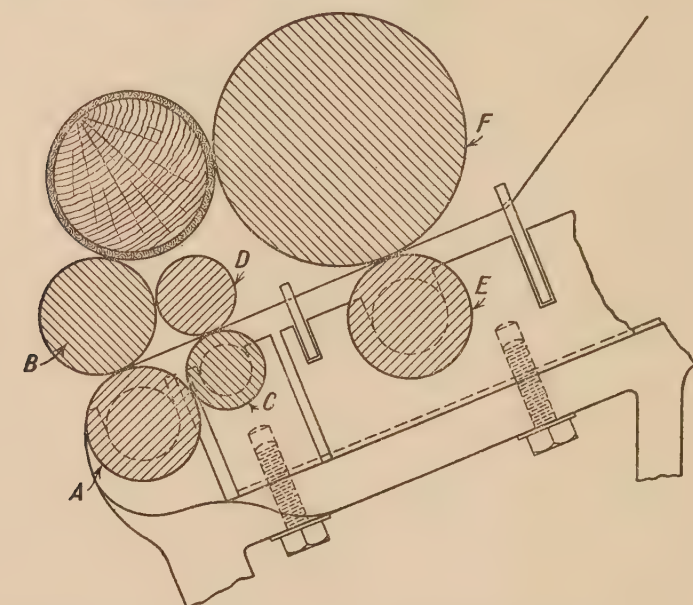
Although the practice of setting well inside staple length with three lines of rollers on the longer cottons when formed into a fine hank roving is, in general, so beneficial, it must not be assumed that, with similar roller arrangements, the practice will be equally satisfactory on shorter cotton and coarser roving, so that some of the important factors operating against obtaining equally satisfactory results under such conditions may now be dealt with.

Fig. 11 shows an arrangement of three lines of rollers of suitable diameters to permit setting inside staple length under these conditions. The employment of rollers of small diameter is necessary, but their use is the root cause of most of the difficulties arising in the high drafting of the shorter cottons by means of rollers. As distinct from the conditions when drafting long-stapled cotton, it is probably true to say that the chief factor governing conditions and limiting possibilities when drafting such cotton is the length of the staple. The use of small diameter rollers necessitates higher roller speeds, resulting in less steadiness in working, increased wear and tear, less efficient control of material, increased liability for unsatisfactory functioning of the top middle roller, and increased liability for roller laps.

The detrimental effect arising from the use of small diameter rollers when dealing with shorter cottons is aggravated by the fact that, owing to the coarser counts produced, the surface speed of the rollers is necessarily increased, the necessity for reduction in roller diameter and higher speed of delivery increasing as the staple length diminishes.

The important factors, other than those mentioned, which affect conditions are, as in the case of the longer cottons, the thickness of the roving, the amount of twist, and the amount of draft. With

short cotton these factors are likely to be of greater importance than with long cotton, more particularly as they affect the work of the control roller, as it is required to control a thicker and harder twisted roving. For the reasons stated previously a single roving of three hank, which may contain 1000 fibres, will require a heavier control



*A* Bottom Front Roller  $\frac{7}{8}$ " Dia.      *D* Top Middle Roller  $\frac{5}{8}$ " Dia.  
*B* Top Front Roller  $\frac{7}{8}$ " "      *E* Bottom Back Roller 1" "  
*C* Bottom Middle Roller  $\frac{5}{8}$ " "      *F* Top Back Roller 2" "

FIG. II.—SPECIAL MOUNTING OF THREE-LINE ARRANGEMENT.

roller than one of five hank, containing 600 fibres, on account of the increased number of fibres over which it exercises a general control, and to prevent interference with its pressure and speed by the larger number of fibres drawn from under it. As the amount of twist-binding effect required, due to reduced length of staple and increased fibre diameter, to obtain the necessary cohesion for strength purposes must be greater on the shorter staple, more resistance to drafting and more disturbance will occur at the control point, requiring the use of a heavier roller if its pressure and speed are to be maintained.

Any increase in the number of fibres being drawn from under

the control roller will tend to necessitate the use of a heavier roller, though, as stated in dealing with the drafting of the longer cottons on the three-line system, the amount of draft and the number of fibres passing forward will influence the weight of roller required, in so far as they affect the setting distance.

Under the conditions existing on medium counts, the difficulty of obtaining satisfactory working of the control roller with high drafts is greater than on the longer cottons, and it may be found that the employment of high drafts under such conditions indicates the inability of the control roller to function satisfactorily, and sets a limit to the useful application of the arrangement. If very close setting is attempted on short cotton and heavy roving, the small control roller necessary introduces a serious possibility of uncertain speed, and the weight which must be applied to obviate this may interfere with the efficient drawing of the fibres and necessitate wider setting.

If drafting action materially disturbs the orderly arrangement of the fibres behind the control roller, the displacement occurring will cause loss of cohesion amongst the fibres in the roving, and possibly stretching, with consequent increased irregularity of drawing. Under such conditions there is a point in reasonably close setting approaching which results will improve, but beyond which they will deteriorate. It is chiefly on account of the limitations of the three-line arrangement, with ordinary rollers on the shorter cottons, that modifications in the character and method of driving the control roller and some of the new drafting arrangements have been introduced. These changes are intended to provide more adequate control of the material, and to allow of closer setting and higher drafts under such conditions.

When high drafting short cotton on the three-line system, it is sometimes considered advisable, on account of the coarse hank roving used, to change the surface character of the top back roller, so as to ensure efficient grip on the roving without necessitating the use of an abnormally large or heavy roller. For this purpose a roller with fine longitudinal flutes may be employed, instead of a smooth one, to establish a very secure hold on account of the thickness of

the roving and the character of the control exercised by the middle roller.

It should be noticed that, with the usual practice of carrying the middle and back bottom roller in the same slide, no change can be made in these centres when the front-roller settings are altered, and, though there may be objections to separate settings for all the three

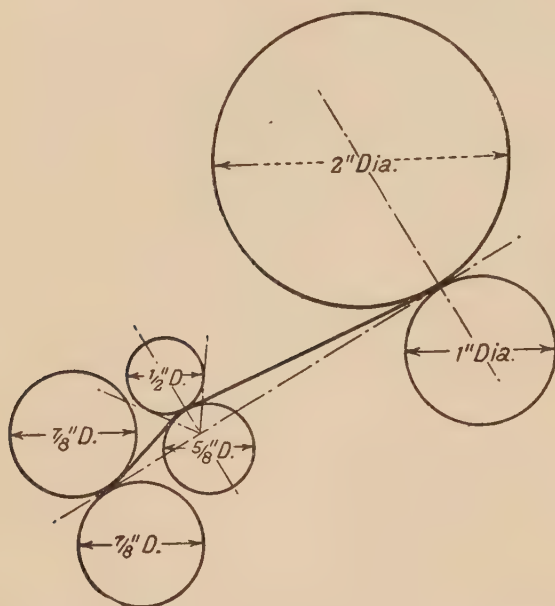


FIG. 12.—BOTTOM MIDDLE ROLLER OUT OF ALIGNMENT.

lines, it might be advantageous in some cases if provision was made for separate adjustment when high drafts are required. Fig. 11 shows an arrangement of the three-line system which provides for separate adjustment of setting distance between each line of rollers.

The position of the back pair of rollers relative to the front pair is a matter of greater importance when a light control roller is employed than when a definite nip is established in the

middle line. In the former case the back setting distance has some relation to the front setting distance, since the drafting action extends beyond the middle line, whereas in the latter case the drafting action of the front line exerts no influence beyond the middle-roller nip. The advisability of varying the distance between the control roller and the previous nipping point has been realised, and in the arrangement shown in fig. 11 is provided for. In three-line arrangements with a light top control roller the setting between back and middle lines may have an important effect on the front-roller setting distance and general drafting efficiency.

Fig. 12 shows a variation of the usual arrangement of the three-line system. The difference consists chiefly in placing the bottom

middle rollers above the plane of the back and front instead of in the same plane. This arrangement of the rollers will keep the material in contact with the bottom middle roller from a point well behind the top centre until it has emerged from the control roller, the amount of contact varying with the height of the bottom roller. This increased contact may assist in the more effective control of the material behind and in front of the control roller. By placing

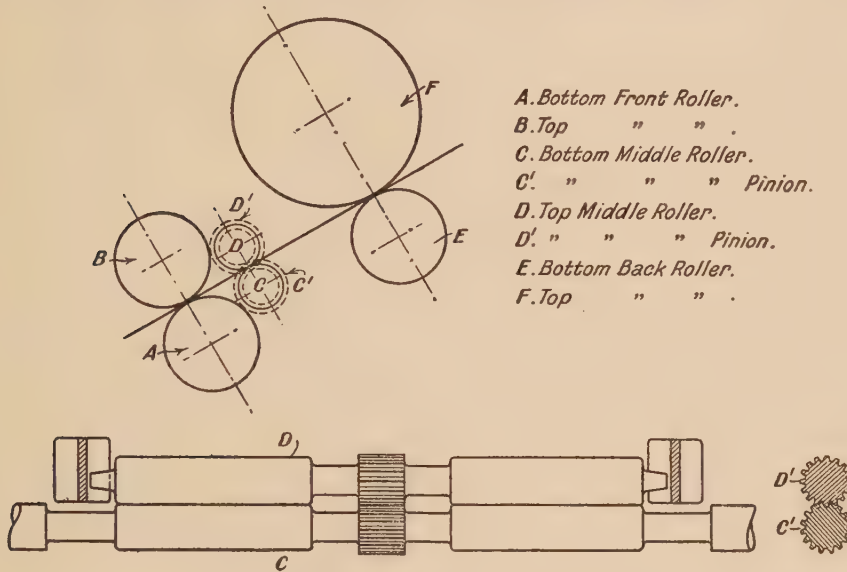


FIG. 13.—GEARED TOP ROLLER (LATSCH).

the top surface of the middle bottom roller above the plane of the back and front, the tendency of the fibres as they are drawn by the front line to lift the control roller is reduced. The position of the control roller can also be arranged so that the fibres are projected almost directly to the nip of the front pair of rollers, thus avoiding the tendency of the fibres to spread, a tendency which arises if the direction of the material is diverted.

The Latsch patented high-draft spinning attachment, which is illustrated in fig. 13, is also a three-line arrangement, but in this case the light top roller is positively driven. Other inventors, as Wild and Johannsen, have introduced patented arrangements to achieve more or less the same object.

In the arrangement shown in fig. 13, the top middle roller being geared to the bottom one, any irregular rotary motion which might arise from the drawing of the fibres from under the roller is prevented. Since by this means one of the factors operating against very close setting is overcome, the setting may be very close providing it maintains adequate control and uniform pressure on the material.

The use of any form of gear to drive the top roller may be regarded

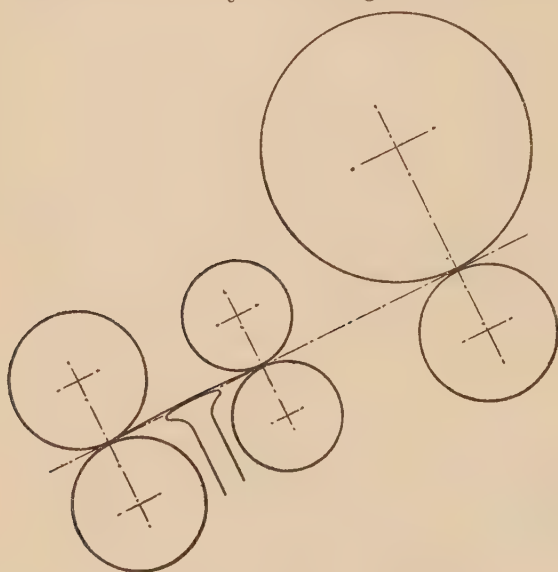


FIG. 14.—BRIDGE-DRAFTING ARRANGEMENT.

as a disadvantage from some points of view. Much, however, will depend on circumstances, and upon the particular means employed for driving the top roller, which may vary from ordinary wheel gears to modified fluting of the roller surfaces at suitable points.

The arrangement shown in fig. 14, known as the Bridge-drafting arrangement, represents another device to obtain better control during drafting. The top surface of the plate

which is placed between the front and middle line is shaped and situated for height so that it may exercise beneficial control over the fibres under drafting action as they pass from the middle to the front rollers. The shape of the plate is designed to allow the middle and front rollers to be set fairly close together, whilst the top surface of the plate, which is as wide as circumstances will permit, provides a sliding surface to the fibres, the contact between the plate and the material being calculated to assist in fibre control and, in this way, in the more regular drawing of the material.

Several of the control rollers referred to previously have been successfully applied to the three-line systems on short cottons, and it is under such circumstances that the need of definite control of

roller speed and modification of the surface character of roller is greatest.

Though, in general, most of the three-line arrangements may be less suitable for the high drafting of shorter cotton and coarser roving than some of the other arrangements, it is possible that, by the introduction of one or other of the various modifications which have been applied, its use may be extended, particularly on medium cotton and medium hank roving.

The adaptation of the three-line system for high drafts must be regarded as a refinement of the usual conditions, and, as such, requires careful consideration of a number of points which do not arise with a similar arrangement of rollers when setting outside staple length. Very careful front to middle roller setting will be necessary to obtain most efficient drafting and to avoid detrimental fibre disturbance beyond the middle line. The advantages of most of the three-line arrangements are their simplicity and familiarity; their disadvantages and limitations are largely associated with the absence of a nipping point behind the control roller near to where drafting action normally terminates. It would seem that one of the inherent weaknesses of almost all the three-line systems of high drafting on short cotton and thick material, which is always operating against very close setting and high drafts, is the possibility of detrimental fibre disturbance behind the middle line.

When light top rollers are frictionally driven it is important that the top clearer should not interfere with their action in any way. The best position for it, under such conditions, is to rest on the back and front rollers and to just clear the middle one, though sufficiently close to keep it clean. If it is not possible by modification of back top roller and clearer diameter to set the clearer in this position, it should rest on the front roller only. When the clearers rest in a stable position on the back and front roller no projections on the cap bars are necessary, and it is possible, and in some cases preferable, to traverse them; this practice is satisfactory when there is little short fibre given off, and it has the considerable advantage that the rollers are more accessible and more continually under observation. Efficient clearing arrangements for top and bottom rollers are very

important; they should be accessible, few in number, and easy to clean; in this respect the three-line arrangement is better than any other. Inefficient clearers allow the rollers to get dirty and allow waste to pass forward with the yarn, increasing the number of yarn faults.

#### FOUR-LINE SYSTEM

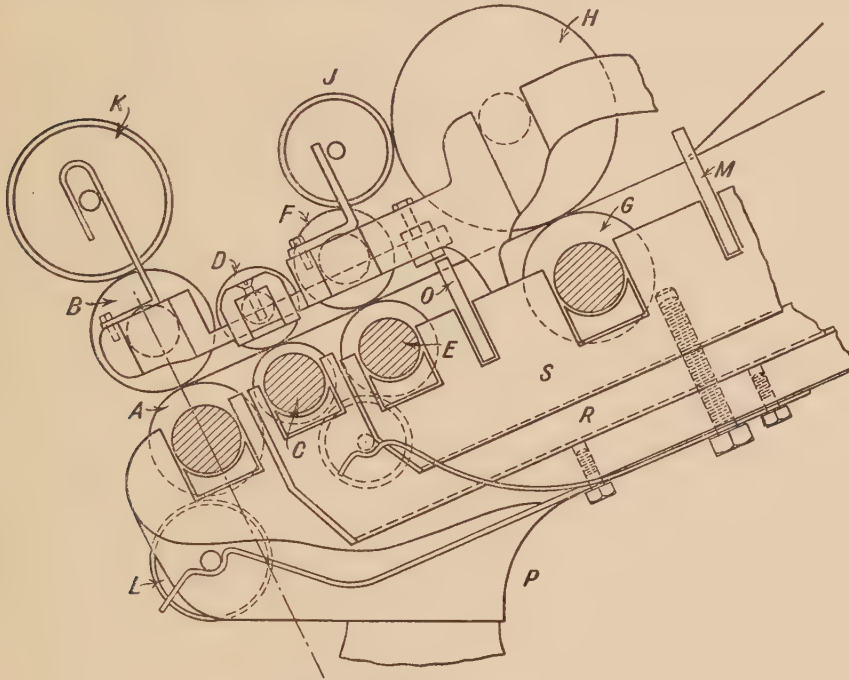
Fig. 15 represents a typical four-line arrangement. In considering the practice of setting inside staple length on the three-line system, it was pointed out that limitations on very close setting might be imposed by the possibility of excessive fibre displacement behind the control roller, and the need for modified means of control, or for an additional and adjustable control or nipping point, realised. This need is greatest when dealing with short cotton and heavy roving, because of the thickness of the material and the greater twist-binding effect in the roving under such conditions.

The four-line arrangements supply this deficiency by providing an additional line of rollers to assist in the more efficient control of the material whilst it is actually subject to the drafting action of the front line. The extra line of rollers is not always intended to provide an additional drafting point; it may, where adequate pressure is applied, allow a break draft to be exerted, but in many cases no more than a tension draft is exercised, all the draft occurring as in the three-line system, as a result of the drafting action of the front rollers.

In fine spinning, in which long cotton and fine hank roving is employed, the extra line provides a second control point at a distance from the front roller nip approximately equal to or slightly exceeding the length of the longest fibres, the additional control point allowing of closer front-roller setting and the use of a lighter control roller.

When dealing with heavier roving and shorter cotton it is necessary to employ rollers of suitable diameter and weight to maintain adequate control of the material. Under such conditions the third line of rollers should be set, on account of the thickness of the material and the amount of twist present, outside maximum fibre length and definitely terminate drafting action.

In all cases a slight increase in the speed from back to third, and third to second line of rollers should occur, not necessarily for drafting purposes, but to maintain tension on the roving as it passes through,



- |                                                                            |                                       |
|----------------------------------------------------------------------------|---------------------------------------|
| <i>A. Fluted Bottom Front Roller <math>\frac{7}{8}</math>" Dia.</i>        | <i>J. Clearer for F and H.</i>        |
| <i>B. Covered Top " " <math>\frac{7}{8}</math>" "</i>                      | <i>K. " " B.</i>                      |
| <i>C. Fluted Bottom Front Middle Roller <math>\frac{5}{8}</math>" Dia.</i> | <i>L. " " A.</i>                      |
| <i>D. Top Front Middle Roller <math>\frac{5}{8}</math>" Dia.</i>           | <i>M. Back Roving Traverse Guide.</i> |
| <i>E. Fluted Bottom Back Middle Roller <math>\frac{3}{4}</math>" Dia.</i>  | <i>O. Middle " " "</i>                |
| <i>F. Top Back Middle Roller <math>\frac{3}{4}</math>" Dia.</i>            | <i>P. Roller Stand.</i>               |
| <i>G. Fluted Bottom Back Roller 1" "</i>                                   | <i>R. Slide for 2nd. Line.</i>        |
| <i>H. Top Back Roller <math>1\frac{3}{4}</math>" "</i>                     | <i>S. " " 3rd. and 4th. Lines.</i>    |

FIG. 15.—FOUR-LINE ARRANGEMENT.

to ensure definite traversing of the material and to some extent to neutralise possible irregularities in the speed of the control roller.

A comparatively heavy or definitely weighted top roller in the third line is required on short cotton and heavy roving, if a break draft is considered necessary, to release some of the binding effect of twist present in the material and to facilitate the efficient functioning of the control roller.

The particulars, as to roller diameter and weight, will be governed by the length of the cotton and the hank roving employed, but the particulars given in fig. 15 are approximately suitable for medium count conditions, and will allow the front and second line to be set to  $\frac{2}{3}\frac{5}{2}$  inch, and the third to front line to  $1\frac{1}{2}$  inches. These settings would, with rollers of suitable diameter, weight, and character, provide efficient conditions for a fairly high draft.

It is probable that the use of a light top roller in the second and third lines of rollers may give the best results on long and fine cotton and light roving, which is only slightly twisted; whilst on the coarser roving and short cotton the use of a light control roller in the second line with a heavier or definitely weighted one, sufficient to set up a definite nip, and to allow a break draft, if necessary, in the third line, will probably be most satisfactory.

In the four-line system facilities should be provided for adjustment of the setting between the two middle lines, because this setting is related to the front setting distance, and any change in one may necessitate a change in the other, even with similar cotton and hank roving; whilst any considerable change in cotton length and hank roving must almost certainly require a change in both. This facility of adjustment is highly desirable, as its absence may restrict the limit of usefulness of the arrangement.

A control roller which may fail to give satisfactory control as a result of interference with its pressure and speed by the withdrawal of fibres from beneath it, with an auxiliary control point, or a definite nipping point, say, at a distance of 1 inch, may with a definite nipping point, or an auxiliary control point set closer, resist such interference.

In any case, where two top rollers, the front one of which allows the fibres to pass forward under the drafting action of the front line, are set to control the length of material subject to drafting action, the work and function of one is directly affected by the working of the other. Any change in the weight, diameter, surface character, or setting of the front one will have a direct effect on the work of the top roller immediately preceding it, and any such change in the back one of the two will similarly affect the light top roller immediately in front.

When a definite nip is established in the four-line arrangement just outside the maximum fibre length, the thick places which may occur in the roving are more efficiently drawn than if a light top roller is employed in the third line, owing to the reduced distance between definite nipping points.

The disadvantages associated with the four-line system arise chiefly from the employment of the additional line of rollers of small diameter, and also, in some cases, the need for additional cleaners. The use of small diameter rollers and the employment of high drafts results in a considerable increase in the amount of fly produced and an increased liability for roller laps. The increased amount of fly given off is common to all high-draft arrangements; it will vary in some proportion to the amount of draft. Any reduction in roller diameter will also tend to increase the amount of fly released and the liability for roller laps, though the actual amount of material lost is not so important as the provision of adequate means for its escape or removal. The possible necessity of an additional under clearer in a rather inaccessible position, under the two middle rollers, and perhaps the necessity of an additional top clearer, are among the minor disadvantages of the system.

The necessity for extra clearers depends upon the conditions; with good material and fine rovings they will be unnecessary, and should only be employed when circumstances necessitate their use, as with the shorter cotton and coarser hank roving.

There is little doubt that, in many cases, the four-line system extends the useful application of high-draft arrangements beyond the limit set by the ordinary three-line system, and may, under any conditions, be superior to it from the point of view of efficient drafting. The retention of the roller principle will, in combination with the other advantages it offers, commend it as a practical proposition. The best results, however, can only be obtained when roller settings, diameter, weight, and surface character of control rollers are satisfactory. All these factors become increasingly important as the draft increases, since the drafting operation becomes an increasingly delicate one.

## CHAPTER IX

### GROUPED ROLLERS

#### GROUPED MIDDLE ROLLER SYSTEM

THE grouping of three intermediate drafting rollers, sometimes referred to as the Gibello system, as shown in fig. 16, provides two pressure points between the back and front lines of rollers, as in the four-line arrangement, without the necessity of employing an additional bottom roller. The same general arrangement of rollers has been employed by several inventors and usually consists of two small diameter rollers resting on the bottom middle one, the distance between the contact points of the bottom and top rollers being approximately the same as between the two middle pairs when very small rollers are employed in the four-line system. The arrangement allows the use of a bottom middle roller of normal diameter, resulting in increased strength, although accompanying disadvantages may arise in connection with the mounting of the top rollers, and particularly of the control roller.

The arrangement of two rollers resting on one, with the material passing between, introduces a change in the character of the control from that existing when the drawing rollers are arranged in pairs, as the material is not left unsupported as it passes forward, but is resting, or to some extent held, under some pressure against the surface of the bottom roller. It is obvious, from the manner in which the material passes forward between the grouped rollers, that the contact of material with bottom-roller surface will keep it in a very compact form, and will tend to reduce fibre displacement as the longer ones are drawn forward by the front roller. The surface of the bottom roller in this case can be regarded in some

measure as the conveyer of the material, which is held in contact with it by the pressure of the top rollers and carried forward at roller-surface speed, no draft between the top middle rollers being possible.

The front middle top roller is usually the lighter one, its weight being just sufficient to prevent the drafting action from interfering with its rotary motion and the pressure it is exerting on the material, but at the same time allowing the fibres which exceed setting distance to draw through. The material between the two rollers being held against the fluted surface of the bottom roller with which it moves, there is less possibility of fibre disturbance occurring than if the contact surface was absent. The maintenance of contact between the material and a moving surface, in this way, is employed in some of the machines in the preparatory process in spinning, and is certainly a factor tending to reduce displacement and keep the material in a compact form.

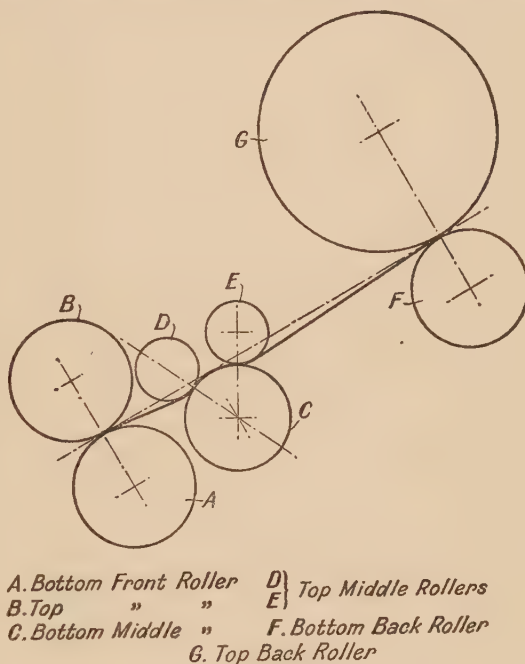


FIG. 16.—GROUPED MIDDLE ROLLERS  
(GIBELLO SYSTEM).

In this arrangement the fibres which exceed front setting distance will, under otherwise similar conditions, offer more resistance to drawing than in the four-line arrangement, on account of the firmer hold exercised on the strand. In both arrangements the fibres which are short or approximately equal in length to setting distance will offer equal resistance, but the longer fibres will offer more resistance in the grouped roller arrangement, the resistance increasing with fibre length to a greater degree than when two middle

pairs are employed. The arrangement, in this respect, provides distinct differences in control which may have added value under certain conditions.

The pressure exerted by the top middle rollers and the character of their surfaces are important, and both will be related to the weight of the material, the character of cotton, the amount of twist, and the setting distance. Their function being similar to the corresponding rollers in the four-line arrangement, the details of them will, in general, be governed by the same considerations. In some cases both rollers may be comparatively light, whilst in others the back roller may, by its own weight, or by pressure otherwise applied, set up a definite nip on the material to permit a break draft. The definite nip of this roller is more necessary on the heavier roving and shorter cotton in order, if required, to release some of the binding effect of twist.

Some consideration may now be paid to the direction the material follows in its passage through the rollers, since this has an important bearing on the drafting conditions. Normally the top surfaces of the bottom drawing rollers are in the same plane, so that, when the top rollers are set perpendicular to the plane of the bottom ones, the material follows a straight path in passing through the several lines of rollers. This disposition, which is the usual one, is not maintained in all the arrangements for high drafting, and is, as has been stated, deliberately departed from in some cases for specific reasons.

When definitely weighted top middle rollers are employed no considerable disadvantage is likely to arise if the material is very slightly diverted below the normal plane, but with light top rollers this should not occur. If such rollers are employed and the contact point of the control roller is below the normal plane, the tension on the fibres as they are drawn from underneath, due to drafting action, will tend to lift the roller.

The possibility of such conditions arising should be avoided in any arrangement of rollers where a light control roller is employed. In the three-line and four-line systems, when the bottom roller surfaces are in the same plane, care is necessary in setting the light control roller relative to the bottom one if the fault is to be avoided. If the control roller is set in front of the perpendicular to the plane of the

bottom rollers, or the point where the material emerges is below the plane of the middle and front, the tension of the fibres being drawn will tend to lift it; any such force will at least neutralise some of the weight of the roller, with possible consequent loss of control. The possibility of drafting action tending to lift a light control roller should, wherever possible, be avoided, as the efficient functioning of the control roller depends upon its pressure and speed being subjected to the minimum of disturbance by drafting action.

With a top roller of considerable weight and the setting equal to staple length the normal position may be departed from slightly without any serious effects arising, but with a control roller which may be applying no more than one ounce pressure for each roving, and a high percentage of the fibres is being drawn from underneath, conditions are totally different, and attention must be paid to the point if good results are to be obtained. To avoid this possibility it might be advisable to set the bottom roller in the three-line and four-line systems so that the contact point of the light control roller is very slightly above the normal plane.

When adaptations of existing roller arrangements are made to permit the use of a much lighter top roller, it is very important that this point should receive attention. In the grouped roller arrangement the path that the material follows affects not only the resistance to drafting and the tendency of the control roller to lift, but also the direction in which the material is projected as it leaves the control roller. To obtain the least fibre disturbance at this point, the fibres should be projected straight to the nip of the front pair, as with these conditions there is the least tendency for them to spread out of effective contact with each other under drafting action. If the fibres are projected in a direction divergent from the direct path to the front pair, there will be greater tendency for them to escape from control and less satisfactory drawing will result. The difficulty of obtaining these conditions and maintaining them in the grouped roller arrangement may be greater than when the rollers are arranged in pairs.

It may be advisable now to consider one or two points which arise when a top roller is set out of the vertical to the bottom one

on which it rests and from which it is driven. When the top roller is placed vertically over the bottom one its total weight is applied at the contact surface, but if it is placed out of the vertical the pressure is reduced, as the weight of the roller is exerting a force horizontally as well as vertically. The roller is held in position by the cap-bar slots, which are usually cut perpendicular to the plane of the bottom rollers. The angular position of the top roller will therefore affect the pressure it exerts, a heavier roller being required to set up the same pressure if the angle is 30 degrees from the vertical than if the angle were smaller.

As a result of excessive inclination, increased difficulty may be experienced in obtaining satisfactory driving of the roller and efficient control of the material as the point of contact between the roller pivot and the cap bar, relative to the plane of the rollers, will alter if the angular position of the top roller relative to the bottom one is changed. The angle at which the slots in the cap bars are cut may, therefore, affect not only the mutual roller pressure set up by any given weight of roller, but also the friction between the roller pivot and the cap-bar slots. The friction between them will be increased by any increase in the weight or angular position of the top roller relative to the bottom one, or in the force necessary to rotate it.

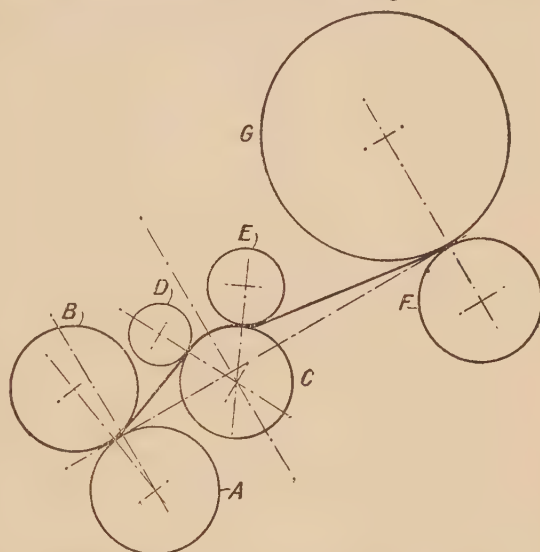
If the contact point between the roller pivots and cap-bar slots is above or below the resultant of the horizontal force due to the weight of the roller and the force necessary to rotate it, a force tending to increase or reduce the roller pressure will be set up. These points require consideration when light top rollers are placed considerably out of the vertical position or their efficient functioning will be impaired, and, to avoid this, in some cases the slots in the cap bars are cut at varying angles to reduce interference with the work of the control roller to a minimum.

It is necessary where light top rollers are employed that the minimum of friction shall be set up and that the pressure exerted when the roller is at work shall be, not only uniform, but, as far as possible, similar to that when the roller is at rest.

The possibility of trouble arising from interference with control-roller speed may be greater if both top middle rollers rest on the

same bottom one than if they rest on separate rollers. In the latter case a slight excess speed of the second over the third line of bottom rollers may help to conceal slight irregularities, whilst in the former case any irregularity or loss of speed may allow the material to go slack. This, besides causing very unsatisfactory drawing, will tend to cause bottom-roller laps, allow the material to move about, and defeat the object of the traverse motion.

In the grouped roller arrangement shown in fig. 17 the usual disposition of the middle bottom roller is definitely departed from, the middle roller being placed well above the plane of the back and front. This may have the effect, according to the height of the roller, of bringing the material in contact with the bottom roller before it passes under the back middle roller, and keeping it in contact with it after leaving the contact point of the



*A. Bottom Front Roller      D } Top Middle Rollers  
B. Top " "      E }  
C. Bottom Middle "      F. Bottom Back Roller  
G. Top Back Roller*

FIG. 17.—GROUPED MIDDLE ROLLERS—WITH  
BOTTOM MIDDLE ROLLER OUT OF ALIGNMENT.

control roller, or it will at least reduce the tendency of tension on the material to neutralise the pressure set up by the roller. The height of the bottom roller and the angular position of the control roller will also have its effect on the direction that the material is projected as it passes to the nip of the front pair. The setting of the bottom middle roller above normal height may be useful in reducing the tendency of the fibres to spread, which occurs when the material is diverted from the straight path.

The diameter and height of the middle bottom roller will obviously affect the setting distance; any increase in its height above the normal plane, or in its diameter, may tend to increase the minimum

setting distance, so that a point is reached when the advantage gained may be more than neutralised by the accompanying disadvantage.

Faults arising from middle roller laps may be more troublesome with the grouped roller arrangement than with the two middle lines, as both top rollers rest on the same bottom one. Since the bottom roller surface prevents, to some extent, the escape of fly from between the two top rollers, the rate at which the fly accumulates on the surface of the rollers may be increased, rendering more frequent cleaning necessary and increasing the liability to faulty

work. Laps of any description on the bottom roller will affect the contact of both top rollers with the bottom roller, whereas when the rollers are arranged in pairs only one roller would be affected, thus increasing the trouble arising from this source.

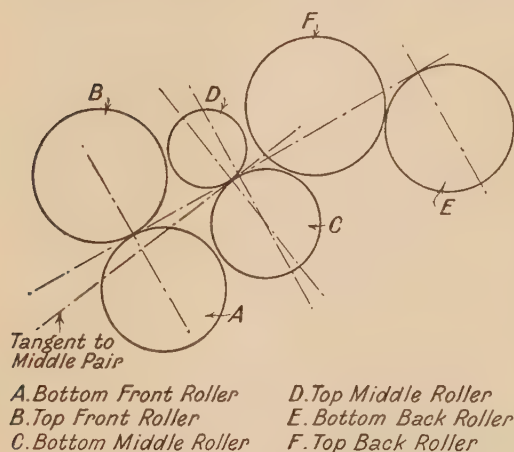


FIG. 18.—GROUPED BACK AND MIDDLE ROLLERS  
(DOUBLE-GRIP BACK TOP-ROLLER SYSTEM).

#### GROUPED BACK AND MIDDLE ROLLER SYSTEM

Fig. 18, which is a variation of the three-line system, and sometimes referred to as the

Double-grip back top-roller system, represents another grouped roller arrangement to establish high-drafting conditions.

It differs in some respects from the one just considered, although it is similar in that two rollers rest in contact with the middle bottom one. It is perhaps the simplest and most rigid of the various roller arrangements in which the usual practice of mounting the rollers in pairs is departed from. The middle bottom roller may be approximately of normal size, only one light top roller being employed. The top back roller, without pivots, resting on the back and middle, operates as the back top roller and the back top middle roller. No provision is necessary for holding the back top roller, as it rests in a stable position between the two bottom ones,

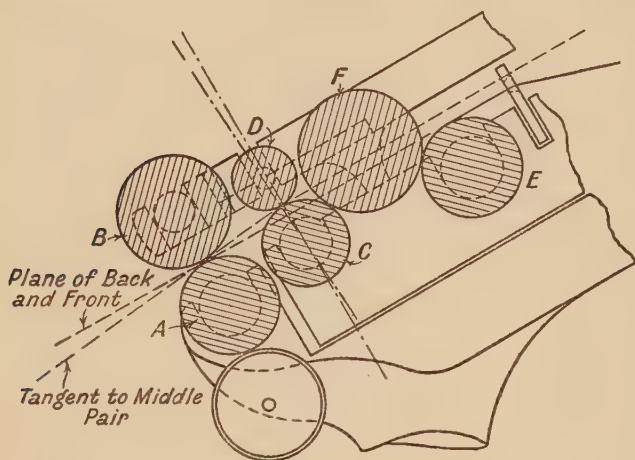
the cap bar keeping it in its place by controlling endwise motion. The back and middle bottom rollers may have similar surface speeds, the top roller resting between them is very definitely driven by contact with the two, and, owing to the double nip on the material thus obtained, it may be lighter and smaller in diameter than usual and yet give the necessary grip to draw the material forward at the definite speed required for drafting purposes.

The continuous contact of the material with roller surfaces, from the point where it enters at the back to the point where it emerges from underneath the light front top roller, with the three pressure points, establishes a control over the material which is in some respects more definite than that obtained in any other type of arrangement. Although the back and middle bottom roller may run at approximately equal surface speeds there may be some advantage in running the middle roller at a slightly higher speed. It may be assumed that some irregularity in the rate at which the material is passed forward may arise under such condition, but this is highly improbable if the excess speed of the bottom middle roller over the back bottom roller is small. A slight difference in speed offers a possible advantage in that the material is kept under greater tension than otherwise, which may assist in the more satisfactory working of the light control roller by ensuring that the material is brought forward under tension.

In this arrangement the control roller is likely to be subject to a tendency to lift, in common with all arrangements in which the control roller contact-point is below the plane of the first and second bottom roller, and it is necessary, as far as possible, to avoid this tendency. To minimise or avoid this fault the middle bottom roller may be set above the plane of the back and front as shown in fig. 19. As stated previously, this will reduce the tendency of the control roller to lift, and affect the direction in which the material is projected, as well as the minimum setting distance obtainable, and there will be less than normal interference to the pressure and speed of the control roller by the action of drawing through.

The arrangement acts fairly efficiently in drawing out thick places owing to the secure grip maintained on the material behind

the control roller. The position of the light top roller can in many instances be fixed to greater advantage relative to the bottom one and to the nip of the front pair than in some grouped roller arrangements, since the position of the back top roller leaves more bottom-roller surface clear. The position of the top back roller leaves the traverse guides in a very accessible position, and if the bar type of traverse guide is employed, the threading of the roving is probably easier than in any other arrangement.



A. Bottom Front Roller  
B. Top Front Roller  
C. Bottom Middle Roller

D. Top Middle Roller  
E. Bottom Back Roller  
F. Top Back Roller

FIG. 19.—GROUPED BACK AND MIDDLE ROLLERS—WITH  
BOTTOM MIDDLE ROLLER OUT OF ALIGNMENT.

The use of a bottom middle roller of normal diameter and the manner in which the material is held will help to minimise the amount of fly and short fibre escaping, and, though less facility is present for the escape of fly than when the rollers are arranged in pairs,

the tendency for roller laps may be reduced, though such accumulations will affect the work of both rollers in contact with it.

With reasonably good quality of material there will be little need for an under clearer under the bottom middle roller. The top clearer should be carried so as to rest on the front roller only, and set just to clear the light middle roller.

The simplicity of the arrangement will probably commend it, particularly in machines of great length, or in which the rollers are less accessible, or where uncertain movement of rollers is most likely to occur.

## CHAPTER X

### SINGLE AND DOUBLE TAPES

#### SINGLE TAPE ARRANGEMENTS

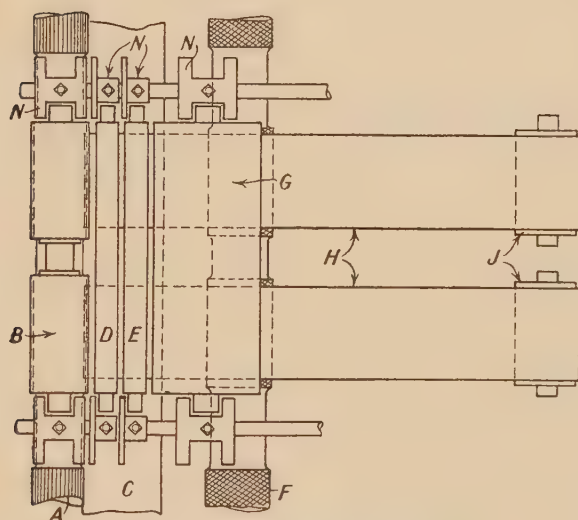
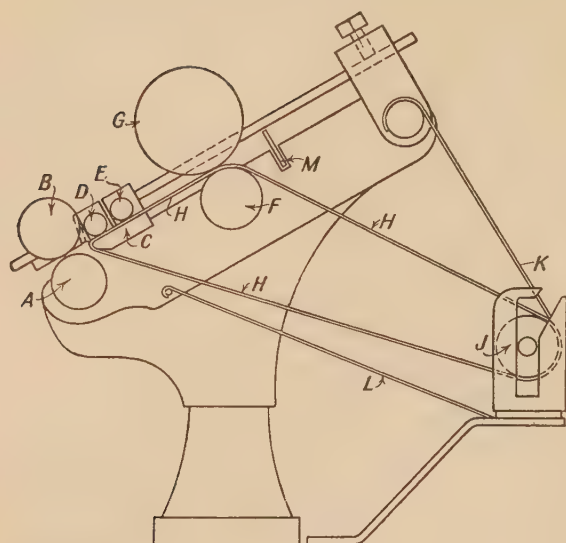
FIG. 20 shows the general arrangement of the Le Blan-Roth system, which is one of the patented single tape devices which have been introduced.

The introduction of a conveyer band or tape as a means of control is a distinct departure from the usual practice of the exclusive use of rollers.

The object of a tape is to obtain continuous contact with the material along the length subject to drafting action. The grouped roller arrangements achieve this by keeping the material in contact with the surface of the bottom middle roller, whilst in this device it is kept in contact with the more flexible surface of the tape by the rollers resting upon it.

In the arrangement shown the tape is driven from the back roller, its regular movement being ensured by the manner in which the back roller surface is cut, the tension applied by the tension roller, and the pressure applied by the top back roller, which is sufficiently heavy to establish the necessary grip to draw the material forward from the creel and for definite drafting purposes. The tape is supported by a smooth metal plate along which it slides, the light rollers resting on the tape as it passes along the plate. The control rollers, which under suitable conditions may be less than  $\frac{1}{2}$  inch in diameter, are held in position and are separately adjustable by cap nebs.

The control of the material and the resistance to drafting is exercised by the pressure set up by the control rollers, which keep the roving as it passes forward from the back roller in continuous



- |                        |                        |
|------------------------|------------------------|
| A. Bottom Front Roller | G. Top Back Roller     |
| B. Top " "             | H. Tape                |
| C. Fixed Plate         | J. Tape Tension Roller |
| D. Middle Top Rollers  | K. Back Cover          |
| E. Middle Top Rollers  | L. Front Cover         |
| F. Bottom Back Roller  | M. Roving Guide        |
| N. Cap Nebs            |                        |

FIG. 20.—LE BLAN-ROTH SYSTEM.

contact, under slight pressure, with the tape. The tapes, which are of highly flexible and durable material, must be accurately made and well mounted so as to give uniform tension, as any irregularity in the thickness or in the tension across the width will seriously interfere with efficient work. Suitable provision is made for weighting and keeping the tape clear of accumulations of waste. The tapes must be kept in a very pliable state, so that they will travel smoothly and rotate the rollers resting upon them at a uniform speed. The tape plate is highly polished and shaped so as to avoid catch places or scraping edges, its top surface being placed so that the material as it emerges from the front light roller is projected straight to the nip of the front rollers, the setting distance being as close as circumstances, such as roller diameter, will permit.

There is a distinct dif-

ference in the character of the control exercised in an arrangement in which the material is drawn over a convex roller surface and one in which it is drawn over a flat surface. In the former case the drawing of the fibres, which are longer than setting distance, over a convex surface sets up an additional binding and retarding force amongst the fibres in the strand which is absent in the latter case.

The object of the back light roller is, as with other similar rollers, to supplement the control exercised by the front one so that any length of fibre can be drawn forward by the front pair of rollers without any detrimental disturbance to the material as a whole.

The arrangement allows of the use of either one or two light top rollers, the weight, diameter, and surface character of which may be varied according to requirements. All the top rollers are carried by adjustable cap nebs, which facilitate the adjustment of setting distance to suit varied staple length and other conditions. An important advantage claimed for the arrangement is that only the top control rollers require adjustment for setting purposes.

The top clearer can be placed in a good working position on the back and front rollers, being well clear of the light middle rollers, the under clearer being also placed in the usual position.

Fig. 21 illustrates the general features of the Vanni system, which is another patented single tape arrangement, the tape being substituted for the top middle rollers. In this case the material is under a continuous, if somewhat variable, pressure between a tape and a roller surface, whilst in the previous system it is only under appreciable pressure at the points where the rollers are placed, between which points the pressure on the strand is very slight. The tape, which is substituted for the top rollers, maintains contact with the bottom middle roller from which it is driven, the material passing forward between the two moving surfaces, in which respect it is somewhat similar to the double tape arrangement. The back and front pairs of rollers and the middle bottom one are approximately the usual diameter and character.

The arrangement as shown usually consists of a tape of leather or other suitable material passing round two rollers, which either

by their own weight, or in some cases supplementary means, keep the belt in tension and in close contact with the bottom roller. The back roller of the two around which the tape passes is placed beyond the drafting zone, sufficient pressure being applied, if necessary, for

break draft purposes. The contact pressure between the tape and the roller should be adequate to control the material as a whole, whilst allowing the longer fibres to draw forward freely.

If no flanges or collars are provided on the tape rollers the local pressure on the material at the points where they rest on the bottom roller will be more definite than elsewhere, as otherwise the pressure results from tension in the tape only. This local pressure effect may be largely avoided, however, if necessary, by the use of collars on the tape rollers. The continuous contact pressure of the tape on the convex surface of the bottom roller will ensure that the resistance to drawing gradually decreases to the point where the material emerges at the front.

The direction in which the material is projected as it leaves

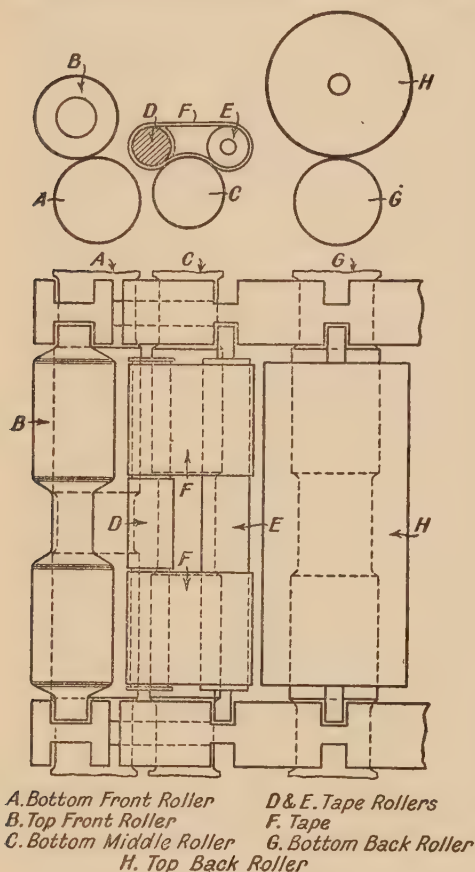


FIG. 21.—VANNI SYSTEM.

the tape at the front will be governed by the height of the bottom middle roller and the point where the tape leaves the roller surface. It is desirable, however, that such details should be arranged so that the fibres are projected as directly as possible to the nip of the front pair of rollers. There are various means provided to ensure effective pressure between tapes and bottom roller, uniform movement of the tapes, and for cleaning their working surface. In one arrangement

the means provided consists of a special roller resting on the tapes, which not only serves the purpose of a clearer, but tensions and guides them also.

If the tape rollers are provided with collars they serve as guides for the tapes, and modify the grip exercised on the material as it enters or leaves them, avoiding localised pressure at these points and anything approaching a definite nipping point. The tape rollers and tapes may be mounted in a trestle or bridge-piece forming a complete unit which is held in position by the cap bar. The arrangement can be readily applied, and is easily removed for cleaning or other purposes.

#### DOUBLE TAPE ARRANGEMENT

The Casablanca system shown in fig. 22 is a double tape arrangement which has received considerable attention. It is in some respects the most interesting of the patented high-drafting methods which have been applied. One of the earliest, if not the first, of the modified drafting arrangements, it possibly possesses greater capacity for the efficient control of widely varying length of fibre than any other type.

The arrangement differs from any of those previously considered in that the material, which follows a straight path through, is controlled by a pair of flexible leather tapes, which carry it forward under a pressure which varies from a definite nip at the back to almost zero at the front. Pressure is applied to the top tape roller by a saddle weighted from the front, in order to obtain sufficient grip to exert a break draft, if required, to release some of the binding effect of twist. As the material passes through, it is subjected to slight pressure between the tapes which carry it forward, exerting an almost ideal control on the displacement of the fibres, and restraining any undesirable movement, until they are individually seized by the nip of the front pair of rollers. The arrangement allows of very close setting between the nip of the front pair of rollers and the point where the material emerges from the tapes, so that the material as a whole is exceedingly well controlled.

The absence of localised pressure at the front of the tapes results

in the restraining influence exerted by them gradually diminishing to the point where the material emerges. The drawing of fibres from between the tapes is essentially different from the drawing of fibres

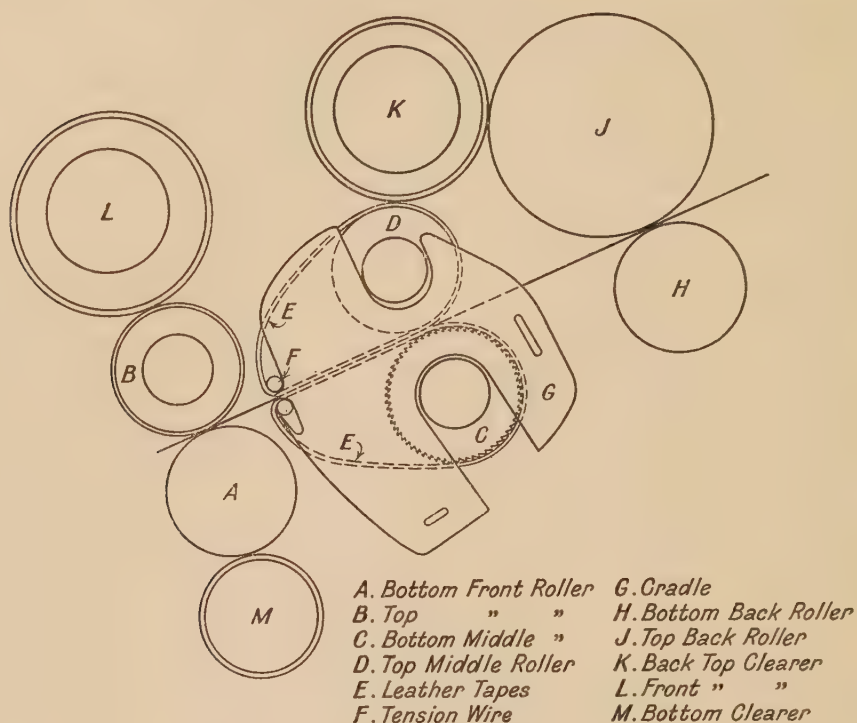


FIG. 22.—CASABLANCA SYSTEM.

from under a roller which is exerting a local pressure, with a relaxed pressure immediately behind, or from between a roller and tape in continuous surface contact extending beyond the drafting zone. In this arrangement the effect is to exert the minimum restraining force at the front and to gradually increase it along the length of the working surface of the tapes to the point of definite nip beyond the length of the longest fibre. The drawing of fibres of maximum length meets with no localised pressure, and their movement will cause the minimum fibre displacement owing to the character of the control exercised on the material as a whole by the pressure between the flexible leather tapes.

As the path of the material is not diverted there is no tendency for the fibres to spread as a result of a change in direction at the critical drafting point. The conditions established probably form the nearest approach to theoretically perfect drafting conditions yet attained, and such an arrangement, all other conditions being equal, is likely to permit a higher draft, or to deal more satisfactorily with material with greater variation in fibre length and character than any other. The arrangement of the tapes also permits extremely close setting to the front roller nip, so that it is capable of being used for the shortest cotton.

An important effect of the use of tapes is the manner in which they cloak or cover the material owing to their flexible character. Reference has previously been made to the difference between the character of the control exercised by a leather-covered roller and a bare roller, and to the advantage of the former in providing a slightly flexible surface. This effect may occur to a greater degree with a single tape than with rollers, but it is with the double tape arrangement that its most beneficial effect is likely to be attained. Providing that the pressure between the tapes is adequate, the material is laid between two highly flexible leather surfaces in contact, which will almost surround the material, but without sufficient grip to hold any individual fibre definitely whilst controlling the material as a whole.

The conveyance of roving under suitable pressure between two flat tapes of flexible and similar material, each definitely driven at the same speed, constitute conditions widely different from those existing in any other of the high-draft arrangements described.

In the latest arrangement of the Casablanca system the method of mounting the parts has been very much simplified to reduce to a minimum the difficulties which may arise from accumulations of waste.

## CHAPTER XI

### BREAK DRAFT

IN dealing with the question of break draft, it may be relevant to consider some points which affect the tension on the roving as it passes into the rollers, such as the friction of the creel peg and the friction set up between the roving and the roving rod and traverse guide.

Experiments show that a roving may extend up to 2 per cent., according to the tension occurring, as it passes from the creel to the rollers. This extension, whatever its amount, is related to the count and possibly the character of the material delivered, and it is desirable that the friction, whilst being adequate to prevent any objectionable slackness, shall be as slight and as uniform as circumstances will permit.

In this connection the position of the creel bobbin, the condition and mounting of the creel peg, the position and number of roving rods, the angle at which the roving passes round the roving rods, and the shape and character of the traverse guide all affect the tension to which the roving is subjected. Whilst it may be impossible, on account of practical difficulties, to avoid some difference in tension arising, everything possible should be done to reduce it to a minimum so as to obtain, as far as possible, uniformity in tension as the roving passes into the rollers.

In dealing with these points, the conditions in the roving frame will be considered, although similar conditions may occur to a lesser extent in the spinning machine. In a roving frame, owing to the use of four rows of bobbins and their position, the tension on the material as it is drawn into the rollers may differ considerably. The tension on the roving drawn from the middle back row is likely

to be definitely less than that from any other row, since it passes forward to the roller with little or no friction contact with either the roving rod or the roller traverse guide. In the case of the roving drawn from either of the top rows of bobbins, the tension is likely to be greater because of the friction set up by passing over two rods at a fairly sharp angle. On account of the position of the bottom row of bobbins, it is often necessary to place a roving rod very close to the surface of the bobbins. This results in the roving being drawn at a very acute angle from the surface of the bobbin, which besides setting up excessive friction between roving and rod, when unwinding from one end of the bobbin, causes the roving to roll on the surface of the bobbin. When this occurs, the rolling contact tends either to increase or reduce the twist in the material at the point where it leaves the bobbin surface, and when this action results in loss of twist the material is weakened when tension may be at its maximum. In view of these considerations it may be doubted whether it is not desirable to modify creel arrangements, if that is practicable, so as to minimise variation in tension on the roving. Whilst some tension on the roving is necessary, the surface character of the roving rod or roller employed, and its height and distance relative to the bobbin, should be such that unnecessary tension and rolling of the roving on the surface of the bobbin is, as far as possible, avoided.

It is evident that if the length of roving between bobbin and rollers, due to tension, may extend 2 per cent. without fibre displacement occurring, it will, under the conditions existing between the back and next pair of rollers, where it is controlled by pressure at two points about  $1\frac{3}{4}$  inches apart, extend appreciably more than 2 per cent. without causing fibre displacement.

If, as is likely, the material will extend under these conditions to an extent appreciably in excess of 2 per cent., then a difference of surface speed, between two pairs of definitely weighted rollers, which merely tensions a roving fed under normal conditions, may cause stretching if a roving passes into the rollers under excessive tension.

It may be inferred, therefore, that to avoid any possible stretching of the material between the back and middle rollers, it is, generally

speaking, advisable to arrange details of roller and drafts so that this is avoided, and that ordinarily the conditions should be such as just to ensure that the material is delivered to the action of the front roller uniform in length and tension.

In high-draft arrangements the amount of twist in the material to be drafted is of greater importance to the efficiency of the operation than with the ordinary arrangements, in which the front roller setting in the spinning machine is approximately equal to staple length. This is because the cohesion amongst the fibres resulting from twist sets up less resistance to drafting in the latter than in the former case, in which the binding effect of twist in the roving may be more or less undisturbed to a point in the strand where some pressure is applied and from which a large percentage of the fibres are drawn. As any increased resistance to drafting will tend to necessitate wider setting, it is desirable that the material at the drafting point in high-drafting arrangements shall be only slightly bound together by twist, so that the setting may be very close and the pressure at the control point as slight as possible.

It has previously been stated that the amount of twist binding effect necessary to obtain the required strength for winding on and off satisfactorily is greater on short cotton and coarse roving than on long cotton and fine roving. The result of this is that the necessity of employing a break draft to loosen out some of the binding effect of twist may be greater on the former than on the latter. The character and thickness of the material under treatment will therefore largely determine the necessity for a break draft as well as some of the details of the high-draft arrangements employed.

Before further considering the question of break draft, it may be advisable to state clearly what is meant by break draft, and to refer to the conditions under which it is usually exerted. The break draft here referred to is the definite drafting action that may occur between the back rollers and subsequent nipping point in speed frames and spinning machines. The setting distance between the points where break draft occurs is usually considerably in excess of the length of the longest fibres under treatment, so that the fibre control which exists arises mainly from the binding effect of twist

in the material, and the consequent mutual surface friction amongst the fibres resisting drafting action.

It may be necessary to distinguish between break draft and what may be called tension draft, which, strictly speaking, is not a draft, if draft implies attenuation by fibre displacement, but only a tensioning of the strand as a whole. Whether break draft or tension draft is exerted depends not only upon the difference in surface speed, but upon the effectiveness of the grip the middle rollers exercise, the distance between back and middle rollers, the character of the cotton, and the hank and amount of twist. The difference between the two, however, in its effect on the material is important. A tension draft can be applied when only slight pressure is exerted, but to exert a break draft a considerable amount of pressure is required, the amount varying with conditions. It is hardly possible to indicate precisely in terms of surface speed the difference between tension and break draft, but it is probable that, under most conditions, an excess surface speed of 5 per cent. does not exert any real drafting action at all. Such a difference in speed merely tightens or tensions the strand as a whole without causing any fibre displacement. An excess speed of 10 per cent. may, however, if an effective grip is obtained on the middle roller, result in some definite, though perhaps slight, attenuation in addition to tensioning the strand as a whole. Anything in excess of a calculated draft of 1.1 at this point would result in a definite draft, which would be related to the calculated draft, with a correction for merely tensioning effect.

The amount the material will actually lengthen before actual drafting action occurs will depend upon circumstances, but that some such lengthening under tension always occurs is certain. What may be regarded as tensioning draft is necessary in almost all circumstances, whilst actual or break draft may or may not be desirable.

As previously stated, a break draft will, in general, be more necessary with short cotton and coarse roving than with long cotton and fine roving, so that some of the twist binding effect on the former may be released before the critical drafting point is reached. The twist binding effect present at the drafting point is also related to the amount of draft on any class of cotton and in any drafting

arrangement; any increase in the draft should, as far as possible, be accompanied by a reduction in the twist binding effect present in the material at the drafting point.

A break draft may to some extent be regarded as an undesirable necessity, in so far as its chief object is to release some of the binding effect of the twist which has been put into the material for winding-on and unwinding purposes. The necessary extra twist put in for these purposes, as has been stated, reduces the length output of the machines and necessitates the production of heavier material and consequently more draft in the spinning machine.

Whilst it is true that break draft attenuates the material, it is very doubtful whether such attenuation, under the conditions often existing when break draft is exerted, can be regarded as really efficient drafting, since it occurs under circumstances which are contrary to those regarded as efficient drafting conditions. To exert any actual attenuation between two points, the distance between which is often appreciably more than the length of the longest fibres, will tend, to a degree varying with the amount of attenuation occurring, to produce more of a stretching than a drafting action. If twist resistance is necessarily high, as on short cotton, break draft may be necessary, but its necessity or desirability on long cotton is doubtful.

If break draft, as distinct from tension draft, is necessary, the character of the material, the binding effect of twist, and the distance between the two points where the break draft occurs are all related to the amount of draft which can be efficiently exerted; and care is necessary if the break draft is to accomplish its real purpose without damaging the material. If a high break draft is exerted under unsuitable conditions, irregularity will be produced before the real drafting point is reached, which will detrimentally affect the character of the yarn.

## CHAPTER XII

### INTER-ROVING FRAME

THIS machine is one of special interest since it represents a serious attempt to reduce the cost of production by permitting a substantial reduction in the number of flyer frames necessary. In this respect, although strictly speaking no high-drafting mechanism is introduced, it has a common object with such arrangements, and any treatment of the subject of drafting would be incomplete without reference to it. The machine is also interesting because it is evidence that the possibility of reducing costs is being seriously considered from more than one standpoint.

The essential difference between this machine and the ordinary frame, from the point of view of drafting, is the double drafting arrangement, the general features of which are shown in fig. 23. This consists of two sets of the usual three pairs of rollers placed tandem on one roller beam, with a device between them for inserting a false twist in the strand. The object of the twisting device is to bind the fibres together slightly as they pass from the delivery rollers of the first set to the feeding rollers of the second set, so as to control the spreading of the fibres and give them sufficient mutual cohesion for efficient drafting.

Improved quality is claimed from the fact that the second set of rollers is fed with a single strand of fibres slightly bound together instead of two separate rovings, thus obtaining highly efficient drafting conditions, and avoiding the spiral effect in the material as delivered, which may occur if two separate ends are fed. The disadvantage arising from the loss of the uniforming effect of one doubling operation may be counterbalanced by the advantage accruing from the changed

conditions of drafting and the reduction in the number of faults as a result of the elimination of a process.

A reduction in the number of faults arising may occur as a result of the elimination of piecing and winding faults which would normally be produced in the machine which is omitted, and on account of the fewer number of creeling piecings necessary by the creeling of slubbing instead of intermediate bobbins. The creeling of the larger bobbins will result in a reduction in the amount of labour involved

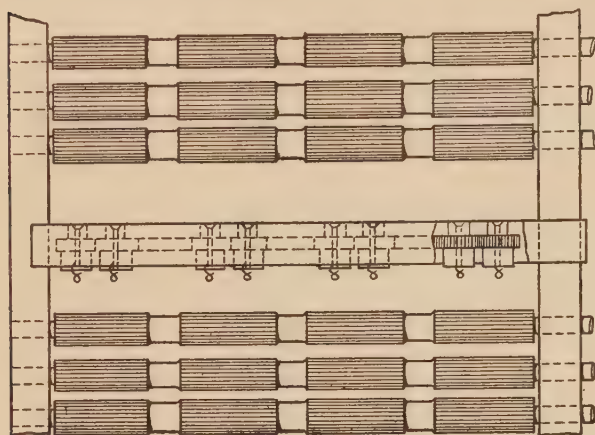


FIG. 23.—DOUBLE-DRAFTING ARRANGEMENT—WITH FALSE TWISTING DEVICE (HETHERINGTON).

in creeling in the inter-roving frame as compared with the ordinary roving frame with equal output.

As the name implies, the machine is intended to exert a draft equal to the actual draft normally exerted by the intermediate and roving frames. Although the drafting mechanism provided is essentially a duplicate set of the ordinary drawing

rollers, there are some important differences in the amount of roller draft and in the general conditions under which such draft is exerted as compared with normal conditions, which may be referred to.

For example, assuming a 36's to 44's range of yarn is to be produced from a .166 hank-drawn sliver, .66 hank slubbing, 1.66 hank intermediate, and 5-hank roving, involving a roller draft of four in the slubbing frame with one end up; a draft of five, with two ends up, in the intermediate frame; and a draft of six, with two ends up, in the roving frame. The total roller draft under these conditions will be  $4 \times 5 \times 6 = 120$  with  $2 \times 2 = 4$  doublings, giving actual draft  $120/4 = 30$ . If no change occurs in the slubbing frame, the actual roller draft in the intermediate and roving frame will be  $120/4 = 30$  and the roller drafts 5 and 6 respectively. If, however, as in the inter-roving frame, only one doubling occurs, the

necessary roller draft will be reduced to  $30/2=15$ , which may be distributed to the best advantage through the double drafting arrangement.

This reduction in total roller draft necessary will allow a very substantial reduction in draft in one or both of the two sets of rollers and tend to improve drafting. An arrangement of drafts to produce this necessary total draft may be as follows: Drafts in back set of rollers—back and middle, 1.1; middle and front, 3.35; tension draft between the two sets, 1.1. Drafts in front set—back and middle, 1.1; middle and front, 3.35, giving a total roller draft of approximately 15, and actual draft with one doubling of 7.5. The drafts are only given as indicating the reduction which may occur, and to show that the drafts throughout may be much lower than would be necessary with the usual arrangement.

A further difference, which may have a very beneficial effect on results, is that the speed of drawing in the back set of rollers is much lower than under intermediate frame conditions. As each delivery unit in the back set is only required to feed one delivery unit in the front set, the speed of the back set of rollers is very low as compared to normal roller speed in the intermediate frame. Assuming a front roller delivery speed of 150 revolutions per minute, and taking the conditions as previously assumed, a front roller speed in the back set of about 36 revolutions per minute would be adequate with middle and back roller speeds of approximately 11 and 10 respectively. This is only one-fourth of the normal speed in the intermediate frame and will tend to improve drawing conditions considerably.

The conditions under which drafting action is exerted in this arrangement are so essentially different from those usually existing that the ordinary rules or practice in the distribution of drafts may be of little help. In this connection it must be remembered that in the back set ordinary twist binding force is present in each strand; the draft and drafting speed are low, and that doubling occurs, a combination of conditions exceptionally favourable to very regular drafting, whilst in the front set the fibres in the single end fed are associated together in a different manner than when normal twist influence is present. Such conditions are so unusual that consider-

able variation from the ordinary arrangement of roller drafts and settings may be necessary to obtain the best results.

The peculiar mechanical feature of the machine is the false twisting device, shown in fig. 23, which consists of a rotating tube carrying a suitable guide, placed between the two sets of rollers. This arrangement inserts binding twist to strengthen the material, to form a round smooth strand, and to guide and support it as it passes to the back roller of the front set. A slight draft is introduced between the two sets of rollers to ensure that the material is kept in satisfactory tension. The mechanism for driving the rotating tube is completely enclosed, as is necessary from its position, to avoid trouble arising from the presence of fly.

The use of the double drafting arrangement results in the elimination of the intermediate frame, representing a 25 per cent. reduction in the number of flyer frames necessary, irrespective of any increase in spindle speed. From the point of view of roller drafting the machine is one of great interest, for, in addition to having some aspects in common with high-draft arrangements, its action sets up drafting conditions which in several ways are essentially different from those usually existing.

## CHAPTER XIII

### COST AND QUALITY

SOME reference has already been made to some of the advantages which may result from the use of high-drafting arrangements. These may now be more fully considered and summarised as follows:—

- (1) From the same mixing—normal quality and count of yarn at slightly reduced cost.
- (2) From the same mixing—slightly finer yarn of normal quality.
- (3) From the same mixing—more uniform yarn of normal count.
- (4) From a slightly cheaper mixing—yarn of normal quality and count.

In addition, the restrictions generally imposed in the making of mixings as to variation in staple length and other features may be less rigid, and the range of counts which may be efficiently produced from a given hank roving increased.

This summary indicates in a general way the directions in which the advantages that high-drafting arrangements provide may be utilised. Actually in practice one or more of these objects may be sought in varying degree according to individual requirements.

No. 1.—The amount of draft which can be employed to produce yarns of equal quality will vary with the type of arrangement and the character of the material. With the longer and more uniform cotton, if sufficiently close settings and adequate control of the material can be obtained without the use of abnormally small rollers, a system of rollers will probably be most in favour. On the shorter cotton, and where greater irregularity in length and other features are more likely to occur, some variation of the ordinary roller arrangement or some arrangement of tapes may be most satisfactory.

Whatever arrangement is used, the higher drafts obtainable will allow some reduction in the number of flyer-frame spindles. To permit the elimination of a complete process, if the high draft is in the spinning machine, it must be equal to the product of the normal draft and the actual draft in the omitted process. It is necessary to ascertain if such a draft can be efficiently exerted before this, which may be considered extraordinary procedure, is decided upon; it has, however, been adopted with success in quite a number of instances, and doubtless will be followed in others. Where such a course is possible the very important reduction in costs is obvious and of great economic importance.

In many existing mills, however, where a full plant is available other considerations may be involved, and it may be better to adopt an arrangement which will permit some reduction in the number of machines at each preparatory stage, and by an increase of draft of 50 to 100 per cent. in the spinning machine produce the same count of yarn. The apparent economic advantage of the latter procedure is less than in the former, but in some cases it may be the best when all the factors have been carefully considered. The actual reduction in costs in either case will be related to the increase in draft in the high-draft machine.

*No. 2.*—The utilisation of high-drafting arrangements to produce a finer count of yarn than is otherwise possible is a matter of importance. Assuming that the increased drawing efficiency obtained with approximately normal draft makes it possible for a yarn of 5 to 10 per cent. finer count to be spun from any given mixing without any depreciation of yarn quality or loss of production, the value of such a procedure is apparent; it would have the effect of reducing the cost of such a yarn, and rendering available, on any given quality and count, cotton which would normally be slightly inadequate.

*No. 3.*—The reduction in yarn irregularity is one of the greatest concerns of the spinner, and any means that will assist in this direction are highly valuable. There are probably many who will be induced to adopt high-drafting arrangements operating with comparatively low drafts from single roving, or with correspondingly increased

draft from double roving, as a means of reducing irregularity in the yarn. Any system which affords improved drawing conditions will assist in the making of a more regular and even yarn, and the increased degree of uniformity which can be obtained by such means will result in increased yarn strength, with equal twist, and improved spinning conditions.

An increase of 5 to 10 per cent. in yarn strength, together with a higher degree of uniformity, will have very beneficial effects on the working conditions in the spinning process, and to the doubler or manufacturer would mean increased output and improved quality of their productions. Any increase in uniformity and strength would greatly improve spinning conditions by reducing breakages, and result in a more regular distribution of the twist. If the increased uniformity gives increased strength beyond the standard required, a reduction in the amount of twist necessary might be possible, resulting in increased output and reduction in cost. In many cases a reduction in twist is highly desirable, either for the purposes of the doubler or the manufacturer, providing it gives a yarn of the required strength. Any reduction in twist would result in a fuller, softer, and more lustrous yarn, all features which, for many purposes, would greatly enhance the appearance and value of the yarn and cloth either in the grey or after subsequent processing.

*No. 4.*—The utilisation of high-drafting arrangements with a comparatively low draft as a means of employing cheaper mixings is a further outlet for their application. In this case original conditions as to the number of spindles and the amount of draft are approximately retained. The increased efficiency of the drafting arrangement allows the use of a slightly shorter, more irregular, or otherwise inadequate or cheaper cotton for the production of a yarn of a certain count without any depreciation in quality or working conditions.

In addition, the restrictions normally imposed in making mixings, as to variation in the length and other spinning features of the material, may not require to be so rigidly observed when efficient high-draft arrangements are utilised. The general advisability of making mixings of this character is not suggested, but there are occasions when circumstances impose the necessity of using such mixings,

and in these cases the improved control conditions will probably produce a better yarn than can be obtained by the ordinary drawing arrangements.

The extension of the efficient drafting range, which high-draft devices provide, is one of the minor claims made for their use. Any possible reduction in the number of different hanks of roving necessary when producing a fairly wide range of counts from a similar quality may be, however, a very considerable advantage in many mills.

It is probably true that in any system of drafting there is a particular draft which represents the best conditions, but under any arrangement or set of conditions this draft may have to be departed from with results which are well known. It is claimed, however, that the increased draft frequently necessary in spinning the higher counts on a given range, which under certain conditions with normal arrangements may produce bad spinning and inferior yarn, can be obtained and perhaps exceeded with high-draft arrangements with less adverse effect on spinning conditions or yarn quality.

It is realised that this method of indicating the various directions in which high-draft arrangements can be utilised is somewhat artificial, but it may be justified for the presentation of some of the advantages claimed. In practice the objects sought are by no means so clearly defined, and one or more of them may be aimed at in varying degree according to individual requirements and circumstances. It is obvious, however, that any change in methods of drawing which gives improved results beneficially affects a fundamental process in spinning, and opens out important issues and possibilities which affect all concerned and which many have proved to be of considerable commercial value.

The object of all high-drafting arrangements is ultimately the reduction in costs of production, but it is perhaps unfortunate that at the outset their introduction was too often associated with the complete elimination of a fly-frame process. That this can be successfully accomplished under certain conditions with some of the arrangements has been proved, but the possibility or advisability of such a procedure under many conditions is very doubtful.

Any increase in draft which is possible will permit a reduction in the number of machines at one or more stages, with consequent economies or corresponding economies by the complete elimination of a process. In the former case the weight of the material produced at each stage would be increased by a reduction of roller draft, giving greater output per spindle and retaining the full number of stages, whilst in the latter case one process would be entirely omitted.

For the purpose of showing the possible effect of the use of high-draft arrangements on the number of speed frames necessary a definite case is taken. In the table shown, No. 1 gives particulars of normal hanks, drafts, and doublings in flyer frames with normal draft of eight in the spinning machine, No. 2 the particulars with heavier material at each stage, with a draft of twenty in the spinning machine, and No. 3 the particulars with one set of flyer frames omitted, with the same final draft.

| No. 1.       |         | No. 2.       |         | No. 3.       |          |
|--------------|---------|--------------|---------|--------------|----------|
|              | Hank.   |              | Hank.   |              | Hank.    |
| Draw Frame   | . 0·166 | Draw Frame   | . 0·166 | Draw Frame   | . 0·166  |
| Slubber      | . 0·66  | Slubber      | . 0·50  | Slubber      | . 0·66   |
| Draft 4.     |         | Draft 3.     |         | Draft 4.     |          |
| 1 end up.    |         | 1 end up.    |         | 1 end up.    |          |
| Intermediate | . 1·66  | Intermediate | . 1·00  | Intermediate | omitted. |
| Draft 5.     |         | Draft 4.     |         |              |          |
| 2 ends up.   |         | 2 ends up.   |         |              |          |
| Roving       | . 5·00  | Roving       | . 2·00  | Roving       | . 2·00   |
| Draft 6.     |         | Draft 4.     |         | Draft 6.     |          |
| 2 ends up.   |         | 2 ends up.   |         | 2 ends up.   |          |
| Spinning     | . 40·00 | Spinning     | . 40·00 | Spinning     | . 40·00  |
| Draft 8.     |         | Draft 20.    |         | Draft 20.    |          |
| 1 end up.    |         | 1 end up.    |         | 1 end up.    |          |

The particulars given indicate the approximate differences that may occur under the various conditions with the draft in the spinning machine as stated, the standard arrangement No. 1 being given for comparison.

To illustrate the effect on the number of flyer spindles required, it may, at first, be assumed that the production per spindle varies

inversely as the product of the count and the square root of the count. On this basis the output per spindle as compared with the standard output would be

| No. 1.               | No. 2.                                                                        | No. 3.                         |
|----------------------|-------------------------------------------------------------------------------|--------------------------------|
| Slubber . . . 1      | $\frac{0.66 \times \sqrt{0.66}}{0.50 \times \sqrt{0.50}} = 1.50 \dots (1.33)$ | Same as No. 1. 1.00... (1.00). |
| Intermediate . . . 1 | $\frac{1.66 \times \sqrt{1.66}}{1.0 \times \sqrt{1.0}} = 2.15 \dots (1.75)$   | Omitted.                       |
| Roving . . . 1       | $\frac{5.0 \times \sqrt{5.0}}{2.0 \times \sqrt{2.0}} = 4.00 \dots (3.00)$     | Same as No. 2. 4.00... (3.00). |

Making allowances for extra lost time due to coarser material, the approximate relative actual increase in production per spindle from each machine is shown in brackets.

The effect of these considerations can be shown approximately by their effect on a preparation of machines set out to produce 500 lbs. of rovings per hour.

In No. 1 for this production on 5-hank roving the approximate number of spindles and machines would be—360 slubbing spindles in 4 frames, each spindle producing 1.4 lbs. per hour; 960 intermediate spindles in 8 frames, each spindle producing .52 lb. per hour; and 3600 roving spindles in 20 frames, each spindle producing .14 lb. per hour.

In No. 2 the production per spindle would be

Slubber . . . 1.4  $\times$  1.33 = 1.86 lbs. per hour  
 Intermediate . . . 0.52  $\times$  1.75 = 0.91 „ „ „  
 Roving . . . 0.14  $\times$  3.00 = 0.42 „ „ „

This would give the number of spindles necessary.

|                    |                               |                    |
|--------------------|-------------------------------|--------------------|
|                    | lbs.                          |                    |
| Slubbing . . .     | 500 $\div$ 1.86 approximately | 270 instead of 360 |
| Intermediate . . . | 500 $\div$ 0.91 „             | 550 „ „ 960        |
| Roving . . .       | 500 $\div$ 0.42 „             | 1200 „ „ 3600      |

In No. 3 the number of spindles necessary would be

|                |                        |
|----------------|------------------------|
|                | lbs.                   |
| Slubber .      | $500 \div 1.4 = 360$   |
| Intermediate . | Nil                    |
| Roving .       | $500 \div 0.42 = 1200$ |

The approximate number of machines required would be

| No. 1.                                                                                                                                               | No. 2.                                                                                                                                              | No. 3.                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Slubber.<br>Frames.<br>4 of 90 spindles=360.<br>Intermediate.<br>Frames.<br>8 of 120 spindles=960.<br>Roving.<br>Frames.<br>20 of 180 spindles=3600. | Slubber.<br>Frames.<br>3 of 90 spindles=270.<br>Intermediate.<br>Frames.<br>5 of 110 spindles=550.<br>Roving.<br>Frames.<br>8 of 150 spindles=1200. | Slubber.<br>Frames.<br>4 of 90 spindles=360.<br>Intermediate.<br>Frames.<br>Nil.<br>Roving.<br>Frames.<br>8 of 150 spindles=1200. |
| The relative amount of machinery necessary would be approximately<br>100 per cent.                                                                   | 50 per cent.                                                                                                                                        | 40 per cent.                                                                                                                      |

If the high draft in the spinning machine is less than that assumed the reduction in machinery would be proportionately less, but with a draft of 50 to 100 per cent. above normal it would be important.

The changes in the number of flyer-frame processes and machines involved in the adoption of high-draft arrangements, as shown in the No. 2 and No. 3 schemes just considered, may have some effect on the general quality of the products which may now be considered.

In terms of uniformity it is difficult to express what real advantage arises from retaining the full number of stages as in No. 2, as the measure of increased uniformity resulting from doubling is difficult to relate to the measure of increased irregularity produced by drafting in the roving processes. It is generally assumed that with normal draft the irregularity increases as the material is reduced in weight in its passage through the flyer frames in spite of the doubling that occurs. On this assumption the irregularity produced must be

greater than can be neutralised by the averaging-out effect of doubling. If this is so, and it is assumed that the degree of irregularity produced is intimately related to the draft, the point arises whether the lower draft necessary in each process, when the full number of processes are employed, will so reduce the irregularity created that it can be neutralised by doubling, or to what extent the contrary tendencies will affect ultimate uniformity. It is certain that with reduced draft in each machine and normal number of doublings the roving produced will be much more uniform than it would be with normal draft, but it is by no means certain that it will be more uniform than the material at the same weight if one of the drafting and doubling stages were entirely omitted.

Though irregularity may be the chief fault which is produced or perpetuated in passing the material through successive stages of flyer frames, it is by no means the only one which occurs. Among other faults are those due to piecings, single and thick ends caused by waste from rollers, clearers, and flyers passing forward with the material. It is difficult to estimate the ultimate effect of all these on roving quality except by careful comparison in actual work. Sufficient has been said, however, to indicate that the question of determining the best procedure to adopt in reducing the number of machines is by no means a simple one, and the real answer can only be obtained by reference to resulting yarn quality under actual working conditions.

It does not necessarily follow that the best results obtainable from the adoption of high-draft arrangements will be realised by employing either abnormally high or abnormally low draft, though in the former case the yarn costs will be reduced, and in the latter case an appreciable improvement in the strength and general quality of the yarn may be expected. The adoption of either extreme course is, in general, probably unwise, as it is somewhat analogous to the use of a very high or very low draft at any one stage, in a complete scheme of drafts under ordinary conditions, between the sliver and the yarn.

The amount of draft that can be successfully employed in ordinary drafting arrangements varies in practice according to the

general character of the cotton, apparently in so far as it affects the fibre control which can be obtained, a long and fine cotton drawing better and permitting a higher draft than a short and coarse one. Improved means of fibre control will also, on any class of cotton, allow an increase of draft without adversely affecting the quality of the drafting.

The improved drafting conditions provided by high-draft arrangements will raise what is usually regarded as the normal draft. It is difficult to determine to what extent the normal draft will be raised, as it will vary with the type of arrangement and the character of the material, but in all cases it is very considerable. If high-draft arrangements raise the normal draft, they will also give efficient drafting over a wider range of drafts than ordinary arrangements. This efficient drafting range will be governed by conditions, but, whatever it is, and whatever arrangements are employed, the best results in any complete scheme of drafts will be obtained by employing drafts within this range, and for this reason abnormally high or low drafts should be avoided.

As with ordinary drawing arrangements, there is with high-draft devices a reasonable range of drafts in which results vary only slightly; below this range, drafting efficiency increases little, whilst above, it decreases rapidly. The range of drafts giving closely related efficiency may be called the efficient drafting range. This range will be wider on long and uniform than on short and irregular cotton, and with any type of arrangement if more efficient control of the material is obtained. The best draft with any arrangement, considered in conjunction with the quality and the cost of preparing rovings, will vary with different cottons, but it will be within the range of efficient drafts.

This increase of efficient drafting range is important, since it has a direct bearing on the number of different hank rovings necessary on any particular quality, and may in some cases, as previously stated, very much simplify mill arrangements by allowing a reduction in the number of hank rovings necessary when producing a comparatively wide range of counts from one quality. This increase of efficient drafting range may not offer the same advantage to the

large and highly specialised mill as to the small or less highly specialised mill; in the latter case the widening of the effective drafting range may represent an important advantage.

Though high-drafting arrangements raise and extend the efficient drafting range so that it is possible, from any particular mixing, to produce a satisfactory yarn of finer count or a yarn of equal quality from inferior material, regard should be paid to the fact that, with any arrangement, the efficient drafting range will be lower and more limited if the material is less uniform in its length and other features. It is therefore desirable, even under high-drafting conditions, to avoid, as far as possible, such irregularities occurring, for the mixing of such cottons under these circumstances is probably as uneconomical and inadvisable as under ordinary conditions.

In any drafting arrangement the amount of short fibre escaping is related to the amount of draft if other conditions are equal. It is therefore to be expected that with high-drafting arrangements the amount of fly given off will be greater than usual. The escape of this increased amount of fly constitutes one of the difficulties arising from the use of high-draft arrangements, and the facilities provided for its escape or removal will doubtless have an important bearing on the type of arrangement used. In this connection the number of parts necessary, the character of the surfaces, the facilities for cleaning, and the extra time lost in maintaining the arrangement in an efficient working condition are all factors to be considered under individual circumstances. The detrimental effect on spinning conditions and on the number of yarn faults arising from the accumulation of fly on or about the drafting arrangements of the various machines is fully realised. It is therefore reasonable to expect those who are seriously concerned with the reduction in number of such faults to hesitate before adopting changes until satisfied that such faults will not necessarily be increased.

It is important, however, to note that the total amount of draft exercised is not increased by a change in the drafting arrangement, but that it will be reduced if a doubling operation is omitted. It can be assumed therefore, from this standpoint, that the total

liability towards the production of such faults is not necessarily increased, for whilst it is increased in the machine where high drafts are employed, it is correspondingly decreased in the preceding machines if drafts are reduced, the total liability being definitely less if one process with one doubling operation is omitted.

The question is not, therefore, as to whether more faults are produced in the machine where high draft occurs as a result of an excessive amount of fly, but whether the change made will, in its effect on the drafting scheme as a whole, tend to increase or reduce the number of such faults in the yarn. The important point is whether, in any high-draft arrangements, the facilities present for the escape and removal of fly are as adequate as those in the standard arrangement. Practical experience generally indicates that the ultimate number of such faults may be greater with high-drafting arrangements, although considerable variation occurs in this respect according to the particular conditions and details of the arrangement.

From this point of view an arrangement of rollers appears generally to be preferable to tapes, but the advantage of rollers in this respect, under some conditions, may be more apparent than real, as although the tapes may allow accumulations of fly in rather inaccessible positions their efficiency may be less detrimentally affected by its presence. The various arrangements of rollers may allow more facilities for the escape and removal of fly, but its presence, in so far as it affects the efficiency of the operation, may be more detrimental than in the case of tapes. For these considerations rollers may be preferable when the amount of fly released is not excessive, as in the case of the medium and better qualities and lighter material.

It is necessary, whilst admitting the usefulness of high-draft arrangements, to realise that, in common with any drafting arrangements, they are incapable of correcting initial faults, and that such faults will be reproduced in a degree varying with the amount of draft. To illustrate the effect of high draft on roving irregularity, assuming drafts of eight and sixteen are exerted on a roving, any original roving fault will be accentuated to a greater degree with the higher than with the lower draft. This does not imply that the higher

draft is less efficient, because perfect drafting merely attenuates the material, its original character remaining, but it indicates that, when high draft is employed, it is of even greater importance than with low drafts that a satisfactory roving should be provided, and it was for this reason that emphasis was previously laid on the possibility of stretching the material in the flyer frames.

When the full number of flyer processes are employed, and a coarser hank roving made, it may reasonably be expected that a more uniform roving will be produced. On account of the need for very uniform roving, it may be that by retaining the full number of processes with normal doublings and less than normal draft many will find the most useful application of high-draft devices restricting, at any rate at first, their use to the spinning machine. The trouble arising from thick places in the material tends to become more serious with the adoption of high-draft arrangements, whether such faults arise from creeling piecings or in any other way. Results will vary according to conditions and the type of arrangement, but in general the hold on the material exercised by high-draft arrangements is more likely to fail than with ordinary arrangements when a thick place reaches the drafting point, and to allow it to pass forward improperly drafted.

This difficulty has been experienced for many years by those who have employed light top middle rollers, and demands special care in the making of piecings as well as the use of a type of roving traverse guide which will prevent, as far as possible, the passage of thick places in the roving. A substantial reduction in the number of creeling piecings necessary will, however, occur as a result of carrying the material forward at a greater weight through the full number of flyer frames, or by the complete elimination of a set of machines.

## CHAPTER XIV

### GENERAL CONSIDERATIONS

THE question as to which, if any, of the various high-drafting arrangements will give the best results under individual conditions is one which, at the present, can hardly be decided by the experience of others. Most of those who have successfully adopted one or other of the newer devices have experimented with and put to a thorough test a number of them, to ascertain their value under their own particular conditions. It is, therefore, a fortunate circumstance that there has been no innovation or development of such importance for many years which can be tested so readily as high-drafting devices.

Considerations of first cost have, no doubt, led to the adaptation of existing arrangements for high-draft purposes, but it is necessary that such changes should be skilfully carried out if successful results are to be obtained. With any system of drawing, uniformity of pressure, speed, and alignment of parts, and a good general lay-out are essential. Any irregularity in these respects would be serious in a three-line system of definitely weighted rollers, but more so in high drafting, which is a refinement of the ordinary drawing arrangement.

It is necessary to realise that any one arrangement may not give entirely satisfactory results under very varied conditions, and that the lack of success with one arrangement does not necessarily preclude the possibility of success with another. It is somewhat early to form very definite opinions on the relative merits of the various arrangements so far introduced for general application on various classes of cotton, or on their relative merits even on similar cotton, but the

extent of adoption of the various systems so far obtained, after careful investigation and extended trial amongst spinners in various countries, is substantial evidence of their value. With some of the arrangements an increase in power is necessary; this increase will usually be greatest when tapes are employed, due chiefly to the power necessary to drive the tapes under the tension and pressure necessary for efficient working.

Any increase in the number of parts necessary, and any change in the character of the control surfaces and method of controlling the material which occurs in the various high-draft systems, as compared with the usual three-line arrangements, requires careful consideration as to the effect on yarn quality and cost of maintenance. Such considerations as first cost, efficient maintenance, liability to derangement, effect of normal wear and tear on efficient drafting, the possible necessity of additional clearing arrangements, extra and more frequent cleaning, and the increased possibility of waste passing forward are all points bearing on the question.

These considerations have inclined some more favourably towards the simpler mechanical arrangements, or the retention of the original arrangement with modification of the weight, character, and position of one or more rollers. The real value of any particular arrangement, however, taking the advantages and disadvantages into account, cannot be definitely ascertained under any particular conditions except by somewhat prolonged practical experience under mill conditions. Such experience alone can determine, on the one hand, to what extent initial disadvantages can be minimised and overcome, and how far the initial advantages can be maintained and improved upon with working experience. There is considerable evidence to show that with some of the more intricate arrangements the initial disadvantages arising from the increased number of parts are greatly minimised when those concerned gain experience of them, and in many cases where they have been in use for some considerable time the ultimate disadvantages are not considered to be of serious consequence.

An important factor to be considered in connection with high-draft arrangements is the gauge of the spindles. It is a much

simpler matter to utilise some of the arrangements when the spindle gauge is  $2\frac{1}{4}$  inches or more than when the spindle gauge is  $1\frac{3}{8}$  inches or less. This is, doubtless, an important factor in favour of the simpler type of arrangement when the spindle gauge is small, as the difficulties arising in work with the more complicated arrangements would be much greater than with the simpler arrangements.

Important differences arise in the application of high-draft arrangements to mules as compared with their use in ring frames apart from spindle gauge. These arise chiefly on account of the length of the machine, the intermittent action of the rollers, and the traverse of the carriage. In the ring frame the length of the bottom rollers is seldom more than 40 feet, whilst in the case of the mule it may be 60 feet, or even more. The greater length of the mule rollers, from the point of view of wear and tear, and the maintenance of small diameter rollers in good working condition will probably create difficulties which would not arise in the ring frame; and faults arising as a result of strained rollers would be more likely to occur on the longer machine.

The intermittent action of the mule, necessitating the frequent starting and stopping of the drafting arrangement, will certainly increase the difficulties arising. In the case of a medium count mule, with roller delivery motion, the drafting arrangement would start and stop eight to ten times per minute, whilst in the ring frame the roller speed is uniform and uninterrupted; this in itself, apart from the length, might be an important factor in drafting efficiency when small bottom rollers are employed.

If light control rollers of small diameter are employed, greater liability of uncertain action will arise when they are driven from a roller which is frequently stopped and started and turned very slowly, as during winding delivery on the mule, than when movement is obtained from a roller having normal, uniform, and uninterrupted speed.

A further difference which arises between mule and ring spinning is that in mule spinning, owing to the traverse of the carriage, less facility and opportunity arises during work for the inspection and picking of the details of the drafting arrangements; this, with a some-

what complicated arrangement, may be an important factor in their efficiency. Though up to the present the application of high-draft arrangements has been chiefly on ring frames, it is not improbable that some of the arrangements may be more generally employed on the mule with success.

It is in the spinning machines that the various high-drafting methods have been chiefly applied, first in an experimental way, and subsequently under commercial conditions. This procedure has been adopted because of the facility with which the change could be made and the results isolated and tested, and because, in general, such arrangements offer the greatest immediate economic advantage by their application to spinning machines. Increased experience has shown, however, that at least some of the methods may be successfully applied to speed frames. Though their application to these machines has not been by any means so general as on spinning machines, some measure of adoption has occurred with either one or other of the arrangements.

The increasing difficulty which may arise in these machines is due to the thickness of the material and the amount of fly given off. There seems, however, no serious reason why a principle which has been successfully applied under widely divergent spinning-machine conditions should not be successful at an earlier stage. There are instances where high-drafting arrangements have been successfully applied to speed frames, but the extension of their application to these machines will probably, for many reasons, only follow the advantages demonstrated by their application to spinning machines.

The various arrangements referred to, the various types of rollers employed, and the methods of weighting and driving indicated do not by any means include all the modifications introduced, but those dealt with are fairly representative of their type. It is well that so much thought and ingenuity is being expended on the process of drawing, for it is a key process in spinning, forming the central feature of a whole series of machines. The introduction and evolution of arrangements suitable for varying conditions is likely to proceed, as there is an increasing weight of opinion that the adoption of some

form of high-draft arrangement has become an important question for all spinners.

The introduction of high-drafting arrangements involves no revolutionary departure from the method of drafting with which the spinner is familiar. The various systems are simply modifications or rather developments of the old type and are based on the realisation of its weaknesses. A study of them is interesting and valuable for its own sake, as to understand them it is necessary to appreciate the fundamental conditions underlying the successful drawing of cotton.

The various arrangements considered represent almost all the types that have been introduced in which rollers or tapes are employed as controllers or conveyers of the material. It is safe to say that, from the point of view of drafting efficiency, almost all of them have some advantage over the ordinary type. Mechanical and other disadvantages may be introduced which will have their effect on the success or otherwise of the various systems, but these are not likely to prevent ultimate success.

High-drafting arrangements will, like all other innovations, have to prove their value against reluctance to change from established conditions, and it is too much to expect that they will meet with uniform success at the outset, but careful investigation will probably convince the majority that the principles of the system are so thoroughly sound that practical application will follow, and such experience under mill conditions will ultimately commend them.

The fact that a considerable and increasing number of mills in many countries have adopted high-draft arrangements and are producing yarn under such conditions is proof of their commercial value, and make it necessary for all concerned to investigate very thoroughly the possibilities of the various arrangements.

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